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ENERGY SYSTEM ANALYSIS PROCEDURE (ESAP).(U)
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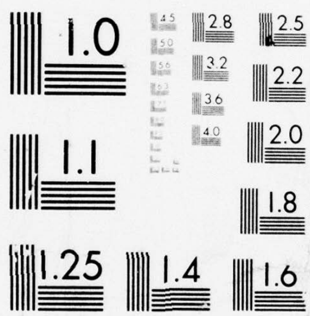
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ENERGY SYSTEM ANALYSIS PROCEDURE (ESAP)

THE DEPARTMENT OF ENGINEERING MANAGEMENT
SCHOOL OF ENGINEERING

UNIVERSITY OF MISSOURI - ROLLA

ENERGY SYSTEM ANALYSIS PROCEDURE (ESAP)

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ABSTRACT

An Energy System Analysis Procedure (ESAP) is developed for determining the impact of energy reductions (shortages) on industrial production facilities participating in Industrial Preparedness Planning (IPP) programs. The total energy requirements for manufacturing activities are analyzed for their effects on production. The method involves programming of the plant or facility in question from the viewpoint of physical units.

TABLE OF CONTENTS

INTRODUCTION

The Department of the Air Force of the Department of Defense (DOD) is responsible for the maintenance of certain industrial capabilities essential to long-term national defense goals. The Industrial Preparedness Planning (IPP) program is established for meeting these objectives and is designed to maintain an adequate industrial base to support DOD requirements for selected essential military items in a national emergency, in addition to the maintenance of selected industrial segments necessary for the long-term national defense. Therefore, an energy emergency (shortage) can substantially affect industrial production in many ways. Production output depends on total energy (direct plus indirect) constraints within which management must choose to adapt and operate. For a more extensive and complete historical analysis of energy and DOD programs, it is suggested that the reader refer to "Historical Analysis of Energy, Policies, and Plant Location, Relating to DOD Industrial Preparedness Planning," September 1976, by John M. Amos, for further information.

An Energy System Analysis Procedure (ESAP) is developed to determine the impact that energy reductions (shortages) have on industrial production facilities participating in IPP programs. The total energy requirements for manufacturing activities are analyzed for their effects on important production, which involves accounting for energy shortages as the raw material flows through all manufacturing stages to the finished production status. The method involves programming of the plant or facility in question from the viewpoint of physical units. To evaluate the procedure, several specific plants are studied.

PROBLEM

Because energy is basic to the economic well-being of every nation, shortages and dramatic price increases since 1972 have had serious impacts on the world economy. In early 1974, the OPEC raised the price of oil exports three to four times over 1972 prices. In addition, revenue per barrel exported rose even more because of either complete nationalization of the oil industry or major revisions of the oil agreements which increased the share of revenue for national governments. Mostly American firms were involved in these actions.

The effect of oil imports was made real during the temporary oil embargos. Unfortunately, almost three years have passed since initiation of "Project Independence," and in these three years we have managed to get farther away from energy independence. In the first part of 1976, the United States crude oil imports were running at the average rate of 4.9 million barrels per day, compared to an average rate of only 3.2 million barrels per day for 1973. The Federal Energy Administration has estimated record oil imports of 5.6 million barrels per day for the third quarter of 1976.[1] Today there is little doubt that energy independence will not materialize before 1990 and maybe even later. Thus, for the near future, the United States will be dependent on foreign energy sources and these imports will be at higher prices, forcing us to spend more and more money on oil imports. This will require a major reallocation of funds within our economy.

The aggravation of inflationary and recessionary problems is already present in the world economy. The direct impact of increased energy prices on world inflation has been estimated at about 2 percentage points per annum while the increase in prices of alternative sources of energy is estimated

to be about 1.5 percent, for a total of 3.5 percent.[2] The increase in the price of energy has aggravated the already existing recessionary situation. An additional portion of income now has to be spent on energy, thereby dampening internal consumption. In addition, modern technology, the basis for much recent economic growth, has been heavily dependent on energy, especially oil, primarily because of its historically low price.

Unfortunately, DOD technology has followed this same trend, i.e., being heavily dependent on energy. An additional problem is that society is required to allocate a greater portion of funds for energy, thereby reducing the tax base and causing reluctance to support large Department of Defense (DOD) expenditures. This situation results in DOD having less funds for development, but at the same time having increased maintenance costs for DOD activities through increased energy prices.

The more fundamental immediate problem examined in this study is that of the effects on supplies and equipment for various Air Force weapons systems from industry during various degrees of energy reduction during a crisis. Several specific questions occur, such as how will an energy crisis affect production in IPP plants in a particular region, what are the critical processes and where located, and what is the ability of IPP plants to respond to commitments during an emergency. Responses to these need to be in terms of volumes and times. This study is directed towards responding to these and similar questions.

METHODOLOGY

The problem of determining the effects of energy on production capacity under varying conditions (especially IPP requirements) is solved by determining them through an Energy System Analysis Procedure (ESAP). The basic industrial structure is modeled in Figure 1. Because of the large number of possible

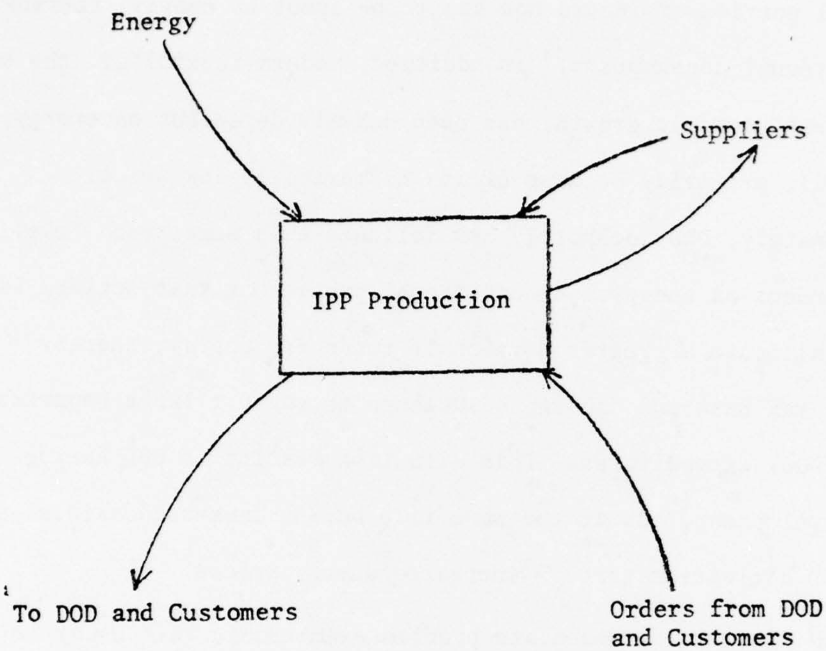


Figure 1. Organization of IPP Production System

combinations involved (energy available, transportation, etc.), an ESAP program provides an orderly computational method of evaluation. Examples of this type of complex problem of multiple alternatives can be found and used in many industries and in the government. Such an approach is based on several premises:

1. Decisions in management and production take place in a framework of information-feedback systems.
2. Intuitive judgment is generally unreliable about how these systems will change with time, even when good knowledge exists of individual parts of the system.
3. Model experimentation fills the gaps where knowledge and judgment are weakest by showing the way in which the known separate system parts can interact to produce unexpected and troublesome overall system results.
4. Enough information is available for an experimental model building approach without great expense and delay in further data collection.
5. The mechanistic decision-making process is true enough so that the structure of policies and decisions of an organization is represented.
6. The organizational systems are developed internally in such a method that creates many of the troubles often attributed to outside and independent causes.
7. Policy and changes are feasible that produce substantial improvement in the behavior and system performance which is often far from what it could be, and initial design changes can improve all segments without compromises or losses from gains in another.

These premises are the basics for developing an approach to the understanding of the effects that energy reductions and changes have on the behavior of IPP production facilities. The interactions between system components are

in many situations more important than the components themselves. Therefore, the information-feedback becomes the basis for integrating the separate facets of the process.

Determining effects of energy shortages involves a complex arrangement of interlocking separate facets. Strategic planning by both Air Force and industry requires preparing for possible eventualities, establishing policies, and determining decisions in advance. No longer can the cause of action be determined and personally calculated; in fact, the system is so complex one cannot determine or select appropriate decisions. Usually one can predict decisions and output; however, today in a rapidly changing world, it necessitates a shift of emphasis to evaluation of alternatives, plant identifications, alerting of resources, assignments, etc. In so doing, it is necessary to interpret tactical judgment and experience of the Air Force, DOD, and management of industry into formal rules and procedures. These methods are necessary because the rapid pace of world technology has created a society that exceeds the ability of man to respond.

It has been amply demonstrated that policies and procedures carefully formulated can lead to decisions that excel those made by management under pressure of time, or having insufficient experience and practice, or in the rigid environment of large complex organizations. There is an orderly basis that prescribes much of present managerial decision-making. Management is not free to make decisions, but is strongly conditioned by the environment. This situation permits one to develop policies and procedures governing such decisions and determine how energy policies and shortages affect the individual and economic behavior and in turn Air Force and DOD policies.

During the last energy crisis, it is well known that shortages occurred in almost all sections of the economy even for products that did not directly

involve large energy inputs. Other times during the energy crisis, it was observed that the system experienced cascaded changes which were amplified by small disturbances that occurred at a given level or for given inputs such as energy. This created amplification of small energy changes affecting production directly and indirectly. Even such a restricted system will contain many of the elements for answers to baffling behavior problems in the real economy.

The system is expressed in explicit quantitative form; the detailed formation of equations represent relationships. After the mathematical description of the system is developed, it can be determined how the system as a whole behaves, by using an arbitrary pattern of energy shortages as an input and observing the resulting effects on final production. The effect on the production system can be obtained by "simulation" methods which consist of tracing through, step by step, the actual flows of activities involved in the system.

The Energy System Analysis Procedure (ESAP) describes the manufacturer's behavior during energy shortages, described in terminology of the real world. Required information is involved and related to the essential characteristic of the firm. In addition, many other quantities are unknown; however, today, managers estimate or combine these intuitively, and in most cases quite ineffectively. The ESAP approach determines the effects of energy shortages, and helps increase our understanding during an energy crisis in an attempt to manage the system.

The procedural system is a simplified flow of information and activities, but even so, realistic and informative results emerge which will provide DOD and industry with effective evaluation of procedures and will avoid costly errors. Unlike real life, all conditions but one or more can be held constant

and a particular time history repeated to determine the effect on one or more conditions that were changed; therefore, circumstances can be studied that are seldom encountered in the real world, which permits investigation of unusual or risky changes.

The ESAP approach follows the same steps that are common to other design techniques. The goals are defined, the significant factors identified, procedure system constructed and tested, and the results analyzed and interpreted. The procedure system must be designed around a goal requiring a visualized description of the interrelated parts of the system. This is not mere statistical procedure but takes place where intuition and insight have the greatest influence. To discover the actual practices, not merely formal relationships, requires experience, alertness, and a strong intuitive feel of the real world activities and operations of the information-feedback systems for the sources of the behavior. This step results in clear, verbal description of the factors and interrelationships involved. Next, these verbal statements are translated into mathematical notations which contain the mechanisms of interaction that have been visualized between the various parts of the system. Problems of conversion to mathematical language arise because of ill-conceived statements and questions, or inadequate and incomplete descriptions.

The tracing of specific time makes possible the generation of specific time history of the behavior that would result if the system (as described) had actually occurred in the real world. It takes the place of the real system and simulates operations under circumstances that are realistic. This permits a great deal more to be learned because the experimental conditions are fully known, controllable, and reproducible, so that behavioral changes can be traced directly to their causes.

In any system, redesign of the system structure and policies to adequately represent the important behavior characteristics requires review and revision.

The ultimate goal of the ESAP is to develop a better intuitive feel for the time-varying behavior of industrial firms with IPP programs during various energy shortage situations, and especially the policy basis that should guide operating decisions.

OBSERVATIONS

Prior to World War II, most firms operated a one-shift schedule; therefore, they had considerable excess capacity. In addition, industry maintained large inventories because of slow transportation, delays, lack of supplies, etc. Consequently, during World War II, industry was able to increase capacity and output immediately by adding shifts, better transportation scheduling, etc. Today, this is no longer possible, as industries are utilizing equipment to full capacity to justify their high investments in facilities and in order to maintain adequate return on investment. Also because of better transportation facilities, smaller inventories are required; in many cases industry operates on only a few days' inventories. During today's energy crisis, production is affected immediately because of the above situation. An additional factor that must be considered is that it will be difficult to adjust and change production because most production equipment in U.S. industry is more highly specialized (designed especially for a given operation) as compared to several decades ago. Therefore, U.S. industry has only limited flexibility. These facts must be considered in interpreting the results.

Today, management does not consider their operations in terms of energy efficiency, but rather their costs. This attitude occurs not only during the production cycle but also during the life use of the product. There is a large difference in energy intensity between products during the production process; for some products require the consumption of

approximately twice as much energy as comparable equivalent products. This condition does not necessarily mean that these products overall are less economic or efficient than others, as other inputs such as labor, capital, land, etc., must also be considered and these high energy products during the production process may frequently require less labor and other resources. In addition to different energy requirements, the energy required to produce similar products may vary considerably between different regions of the nation. During an energy shortage, immediately the most efficient productive units would attract greater amounts of scarce energy supplies; therefore, an energy shortage would be felt first by manufacturers using energy inefficiently.

With an overall energy reduction, major production shifts should occur among the nation's productivity units; however, this analysis is heavily dependent on non-governmental intervention in the energy market and assumes that energy would be allocated by the market mechanism which would make the best use of the scarce energy.

The present government allocation system for energy completely changes the above analysis of energy distribution through the market mechanism, which would be the type of energy distribution management and policy makers would assume. The present government system is an allocation on past average usage rates. For example, if a firm had inefficient production equipment and/or buildings without insulation or in poor repair, the energy usage would be reduced the same percentage as the firm having highly efficient production equipment and buildings. No provisions are made in the allocations for efficient use of energy. Therefore, no methods or means are provided in the analysis for efficiency versus inefficiency of production facilities.

SOURCES OF DATA

Data and information were obtained from interviews with typical organizations participating in IPP programs. A list of organizations participating in IPP programs was obtained from the Register of Planned Emergency Producers, (Office of the Assistant Secretary of Defense, Volumes I, II, III, DOD 40053-H, April 1975). From this source, twenty-six organizations were pre-interviewed concerning IPP programs, their operations, use, etc. From these a sample was selected to provide data for the ESAP and the case example presented in the context.

When data for a peculiarly sensitive parameter was used, there were more problems than merely measuring its value, which could be measured accurately, but the value generally is not constant with time. Thus, an important variable may cause the ESAP behavior to be misleading at times. An attempt was made either to determine the source of variation or its control, and if these were unsatisfactory, then the system was redesigned so that the ESAP behavior no longer was vulnerable to the value of and changes in the parameter through utilizing smoothing techniques, further information, etc.

Descriptive information was obtained for construction objectives. This important source does not exist as "data" in the usual sense of tabulated statistical data. In this manner, plausible numerical values are assigned to represent identifiable and describable characteristics of the real world. These relate individual policies and characteristics to the consequences that they imply.

During the process it was necessary to determine the relative importance of various factors. Data was obtained relative to changes in value within a range of present operations; obtaining data or refining for operations outside the range would be unjustified as these operations generally are unprofitable.

Because of the nature of some of the data required from management, values were estimated where necessary, so that information could be obtained as speedily as was feasible. In general, sufficient information and data existed of descriptive knowledge by management for the study. In fact, management was very sensitive to the preserving of important variables concerning energy and IPP programs; and there was divulged far more useful information than existed in recorded data. This does not mean that data collection was not justified, because it was used extensively in the process.

PROCEDURE METHODOLOGY

The "Procedure" is general in nature and represents a broad industrial base. Because the immediate objective was an examination of possible effects or unstable behavior arising from the energy shortages, pertinent factors relating to energy were included in the procedural formulation. Some principal organizational relationships and management policies were not included but would have been interesting, and some might seem essential. Because of the critical importance of the structure in contributing to the system, the analysis includes the principal activities, delays, etc., in the flows of energy through the system. Sources of expansion and contraction were incorporated, as these are crucial to the behavior of the system in the real world. Such factors found in the system affect the generation of production, shipments, energy, etc.

A system of equations was developed in the context of certain conventions that state how the equations are to be evaluated. These equations control the changing interactions of a set of variables as time advances and are computed periodically to provide successive new states of the system.

The continuous advance of time is broken into equal monthly intervals. This means that changes made at the beginning of the interval are not

affected by any changes that occur during the interval. At the end of the interval (month) new values of levels are calculated and from these, new rates are determined for the next interval (month).

For the purpose of evaluation, the basic equations are separated into flow equations and quantitative equations. For each time step, the quantitative equations are evaluated first, and the results become available for use in the flow equations.

Delay equations are used to introduce a time lag, a conversion process that accepts a given inflow and delivers a resulting flow of output. Many delays are short and their effect is negligible compared with longer delays. However, to introduce a delay in every situation would lead to a vast amount of detail, much of which would contribute little to systems behavior. Actual processes which are cascaded one after the other are often combined into a single delay representation. Also, delays in parallel branches entering a common channel may often be combined.

It is obvious that the "Procedure" cannot possibly represent every individual decision and transaction taking place in the system. If individual actions are properly grouped according to similarity of circumstances, the average behavior can be more accurately described than can be accomplished for any individual incident. How this grouping, or aggregating, is done is of the greatest importance. If there is insufficient aggregation, then unnecessary and confusing details occur; however, if aggregation is too sweeping or is accomplished by combining the wrong things, then elements of dynamic behavior are lost that need to be observed.

Even though a great degree of aggregation occurs, energy types, supplies, products, customers and production are segregated in the procedure. Only those items are aggregated that have similar characteristics either in decisions or time response, functions, etc., which preserve the important

nonlinearities of the system. Aggregation was based largely by examining these factors. Individual activities and sequences are formulated in the procedure; therefore, flow diagrams were developed for the sequence of individual actions. This involved paths of events, formations, delays, backlogs, shipments, and production. Through this method, the establishment of aggregation of separate items is possible.

Changes occur from the reduction of energy into the system in proportion to the level of energy usage. It is assumed that a decrease in energy available requires a corresponding decrease in production and causes a decrease in suppliers' production, as it is assumed these groups are already practicing energy conservation measures. In addition, the decreased level of activity causes transit problems, as the transit sector has less energy available. Reduction of energy at production requires short-term, transient decreases at both suppliers and transportation sectors.

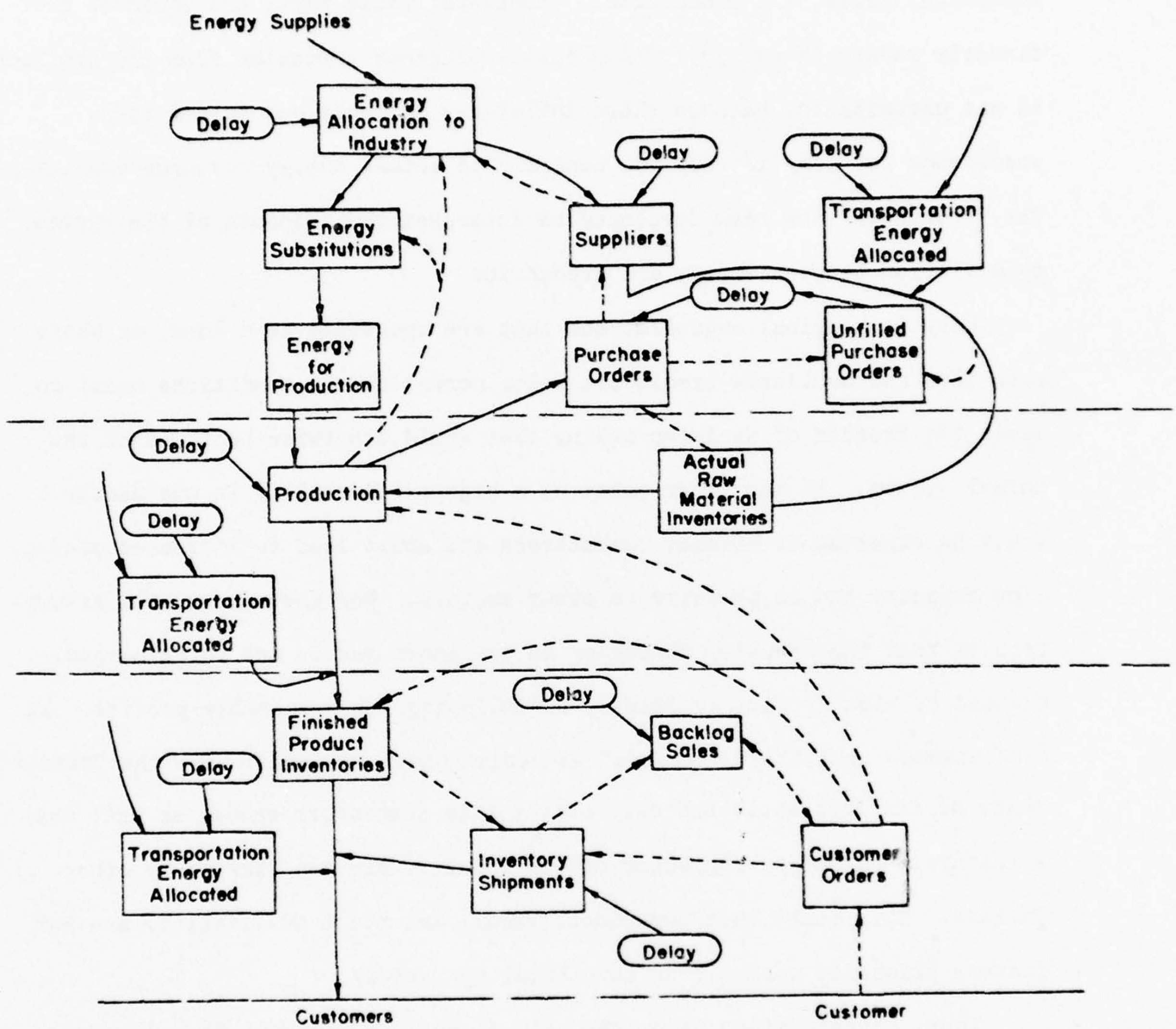
Changes arise from inventories--a decrease or shortage of products usually creates a desire to carry a higher reserve or supply of materials. These can be acquired by additional purchases for a time in excess of present inventory levels. Such factors operate to cause an artificial demand and supplies fall faster than expected.

Besides reduction of energy for production, management thoughts and actions also lead to further changes and further instability of the system. For some this occurs as a major source of change in the system, even more amplified than in the real world. The general approach in the "Procedure" is to allow sufficient scope to contain interesting dynamic problems. The emphasis of the system is restricted to the bare framework and major phenomena of the system; unimportant detail obscures the principal reason for the system. Otherwise, extensive enrichment of internal details leads to a more complex situation that detracts from the overall objectives of the system.

Activity in the "Procedure" consists of interacting flow networks of energy, production, and flow of materials. The materials flow is controlled by many interacting relationships representing information based on inventories, sales, and production. Therefore, those parts are included that directly relate to energy. The omission of other variables from the decisions is not unrealistic, because these influences on decisions seldom take precedence for long if they run contrary to actual energy resource conditions. The "Procedure" has been developed to interpret the response of the system to deviation between energy and production.

Only in marginal organizations that are operating at a loss, or where cash flow and available credit are below normal do the conditions exist to limit the freedom of decision-making that would otherwise be found in the normal system. At the other extreme, a high profitability in one sector would be expected to attract competitors and would lead to increased production capacity and to pressure on other sectors. For the moment, the assumption is that the industry character in the short run is not being markedly changed by high profits or losses, but allowing for reasonable profits. It also assumes that the "Procedure" is dealing with an industry in the "Mature" phase of its life cycle and only over a time span short enough so that the structural and policy character of the industry are not changed by other factors. This means that personnel, labor, and plant availability are not factors primarily controlling industrial operations.

Thus, concentration is on the main channel of material flow (which includes energy) from production plant to customer and DOD and on the streams of information flow moving through the systems. The structure of the system is shown in Figure 2. The system is concerned with four major types of energy--natural gas, coal, oil, and electricity; therefore, the diagram involves a similar diagram for each energy source. This defines in a general way the problem facing industry when energy supplies are reduced.


Energy Supplies
Delay
Energy Allocation to Industry
Delay
Delay
Energy Substitutions
Suppliers
Transportation Energy Allocated
Delay
Energy for Production
Purchase Orders
Unfilled Purchase Orders
Delay
Production
Actual Raw Material Inventories
Delay
Transportation Energy Allocated
Delay
Finished Product Inventories
Backlog Sales
Delay
Transportation Energy Allocated
Inventory Shipments
Customer Orders
Delay
Customers
Customer

Only the most pronounced and obvious influences are included. The purpose is not to achieve complete representations of all functions, but rather to exhibit a method of analysis and to understand the contributions to system behavior that can cause organizational problems.

The ESAP has the following characteristics:

1. Describes cause-effect relationship for various energy types.
2. Is simple in mathematical nature.
3. Is closely synonymous to the industrial terminology.
4. Can extend to large complex situations.
5. Includes a continuous interaction of energy-related activities.

The structure contains the following essential features:

1. Customers of several levels of activity, DOD, IPP manufacturing units, and suppliers.
2. Flows from one level to another of information, materials, etc.
3. Decision points that control activities in the structure. These are statements of policy that determine response to conditions.
4. Information sources that connect the structure.

This is an effective means for studying a complex phenomena. The value arises from its improving understanding of obscure behavior characteristics more effectively than can be done by observing the real system.

In this analysis, the customers (including DOD), production, suppliers, and energy sources, make up the sectors, which are very similar to one another. Equations are formulated to represent the relationships of component concepts that are significant in describing the system.

Included are variables that measure quantities which are levels in the system, such as inventories, backlog sales, energy, supplies, etc. Likewise significant in the system are flows; by implication this involves the important decisions, both implicit and overt, which are being made. In

addition, there are important delays that contribute to the system's behavior. Mathematically, the delays take the form of equations of quantities and flows.

In approaching the actual situation of energy shortage, considerable time was taken in tentative identification of the pertinent variables, in reducing these to equation form, and in selecting the factors that were to be included. Within the confines of this report, there is not enough space (it would also be unduly confusing) to attempt to trace all of the steps that were actually followed in evolving the equations.

A. For the customer and DOD sector, quantities that are central are:

1. Backlog sales.
2. Inventory.

Correspondingly, the major flows pertinent to the objectives are:

1. Orders from customers and DOD.
2. Inventories shipped.
3. Orders to production.
4. Transportation to customers and DOD.
5. Transportation from production.

The principal delays for these quantities and flows are:

1. Delay in inventories shipped.
2. Delay in transportation to customers and DOD.
3. Delay in backlog sales.
4. Delay in transportation from production.

B. The production sector involves quantities set forth as follows:

1. Actual raw material (RM) inventories.
2. Unfilled purchase orders from suppliers.

The major flows for this sector are:

1. IPP production.
2. Purchase orders to suppliers.

Delays in the production sector are:

1. Delay in purchase orders to suppliers.
2. Delay in IPP production.
3. Delay in transportation from suppliers.

C. The suppliers sector uses quantities factors as follows:

1. Supplies shipped.

For the suppliers sector, the flows are:

1. Supplies production.
2. Transportation to production.

Delays for suppliers are:

1. Delay for supplier production.
2. Delay for transportation to production.

D. The energy sector quantities include:

1. Energy for production.
2. Energy for suppliers.
3. Energy for transportation.

The flows that are involved in the energy sector are:

1. Energy allocation.
2. Energy substitution.

And the delays are:

1. Delay in energy allocation to industry.
2. Delay for transportation.

It must be stressed that the equations are not correct in an intrinsic or mathematical method. These merely describe what appear to be the most significant relationships and are similar to a verbal description of organizations having IPP activities. They are correct from the standpoint of interviewers' perceptions of IPP programs and relationships to the organizations' activities.

As stated, the procedure only incorporates the important factors relating to energy shortages and includes factors that are highest on the priority of effects within the above specified boundaries. This represents the estimate of sampled management of IPP programs of the behavior of the existing systems with the characteristics represented of the system's behavior to be explored. The usefulness of the procedure depends on its reasonableness and pertinence.

The next step is to attempt detailed measurements for the importance of factors that influence activities considerably. In this way, costly data collection and data analysis can be concentrated and directed where the results will be most useful. Some factors do not influence to the extent that others do; consequently, the values do not matter as they do not affect the system's operations critically. These do not require such effort of data collection and this particular aspect is not directed to in this study.

Industry is characterized by irregular events which are influenced by a multitude of minor events. These irregularities are caused by many activities that exist in the organization. On the other hand, many managerial actions must react smoothly. Production cannot be permitted to fluctuate as inventories are built up and decreased slowly.

Changes in data, while ignoring the superimposed, meaningless fluctuations, require averaging (smoothing). Averaging of data occurs to some extent at all points in the procedure. In turn, each of these same points contributes its source of fluctuations to the points or activities being controlled. The mechanism for smoothing is the numerical processing of data into averages, monthly, quarterly, and annual summaries of sales, production, energy usages for the period specified. These formal averaging processes are found in many points and channels of the procedure.

Smoothing is essential for filtering out short-period fluctuations; however, smoothing changes the sensitivity of the procedure to different periodicities that may exist in data fluctuations. Smoothing distorts for better or worse the information in a system; consequently, it is always a compromise. The dilemma is between more smoothing to reduce meaningless fluctuations and less smoothing to extract the desired, meaningful information.

ALGORITHM

Data Input

This type of analysis requires data that is easily available. The assumption is that adequate data is available and that extensive collection of statistical data is unnecessary as the value from the laborious collection of data generally does not equal the cost.

The actual data requirements for input to the evaluation program are described in Figures 3 through 9. These figures show the input format, input variable names and descriptions, and purpose of each of the 14 input cards to the algorithm.

Figure 3 describes the historical data card, which is of crucial importance due to the recursive nature of the equations. This card provides past manufacturing data on number of products ordered each period, number shipped each period, average distance the product is transported and finished product production cycle time.

Figure 4 describes the product. The name of the product is used for output identification. The number of units produced is used in calculating a fuel per unit ratio and the equipment age is included in the calculation of a delay caused by the increased down time of older machines. Any special fuel requirements which are incurred prior to production must be deducted

PURPOSE: This card provides the program with information to initialize data to the arrays INVSHP, BLGSAL, and ORDERS. It also contains data concerning special orders, average monthly orders received, average distance transported, and monthly product cycle time.

FORMAT

COL 1-10	INVSHP(2)	Number of finished products shipped last month, I(10).
COL 11-20	BLGSAL(2)	Backlog on orders prior to this month's shipments, I(10).
COL 21-30	ORDERS(1)	Number of units ordered two months ago, I(10).
COL 31-40	ORDERS(2)	Number of units ordered last month, I(10).
COL 41-50	DODCOM	Number of units committed to a special order, I(10).
COL 51-60	AVEORD	Average number of products ordered each month, I(10).
COL 61-70	DIST	Average distance finished products are transported, I(10).
COL 71-75	PRODCY	Product cycle time (in months), F(5.3).

Figure 3. Historical Data Card

PURPOSE: This card provides the program with information about product name and monthly quantity produced, any special fuel requirements, age of production equipment and type of transportation employed for shipping.

FORMAT

COL 1-16	PROD 1	Name of product manufactured, A(16).
	PROD 2	(Due to the character handling characteristics
	PROD 3	of FORTRAN, four variables must be used to
	PROD 4	contain a sixteen character name.)
COL 17-26	UNITS	Quantity of finished products produced per month, I(10).
COL 27-28	EQAGE	Average age of all production equipment, I(2).
COL 29-37	SPNLP	Special fuel requirements which are used prior
38-46	SPNNG	to production, 5 F(9.1).
47-55	SPNOIL	
56-64	SPNCL	
65-71	SPNEL	
COL 72-75	LTRANS	Type of transportation used to ship product, A(4).

Figure 4. Plant Information Data Card

from the total energy available prior to production output calculations. Finally, the method of transportation used is important in order to figure the diesel fuel requirements.

Figure 5 describes the energy required and available for production. A random percentage of a fuel change is applied to the normal fuel requirements in order to determine energy available for that month.

Figure 6 describes the plant volume and energy substitution possibilities. The physical volume of the plant is used to determine the heating BTU requirements. This heating requirement is then deducted from fuel available for production. Energy substitutions are made through predetermined ratios if the manufacturer has adequate facilities and sufficient access to the fuel.

Figure 7 describes diesel fuel availability, the types of raw materials (if more than 100 different materials are used the dimensions on variables RMU, RMINV, and RMUSE must be altered accordingly), inventories, and usage requirements. The diesel fuel available determines the quantity of finished products the manufacturer may transport. Limitations in production output may occur when inventory levels fail to meet the raw material demand requirements. Thus, the beginning and ending inventories for each material are important enough to necessitate careful monitoring.

Figure 8 describes the number of suppliers for each raw material and the amount of fuel available to each for production.

Figure 9 describes the supplier, the name of which is used strictly for printing purposes. The number of units the manufacturer orders along with the percent of the supplier's total output and the supplier's fuel requirements determines the quantity of raw materials which are available for delivery to the manufacturer. The product's unit weight, distance transported, and transportation method determine the quantity of raw materials actually delivered and added to the manufacturer's inventory.

PURPOSE: This card provides the program with information about the quantity of each fuel, liquid petroleum, natural gas, oil, coal, and electricity, which is consumed in normal production and the change (in percentage) to be observed.

FORMAT

Card 1

COL	1-15	QLP	Quantity of each fuel consumed in producing
	16-30	QNG	UNITS units, F(15.1).
	31-45	QOIL	
	46-60	QCOAL	
	61-75	QELECT	

Card 2

COL	1- 7	CLP	Percent change to be effected on the above
	8-14	CNG	quantities, F(7.4).
	15-21	COIL	
	22-28	CCOAL	
	29-35	CELECT	

Figure 5. Energy Data Card

PURPOSE: This card provides the program with information about the plants interior volume and type of energy used for heating and cooling.

FORMAT

COL 1-15	SPACE	Volume of the production facility, F(15.1).
COL 16-19	IHFUEL	Type of energy used for heating, A(4).
COL 20-23	ICFUEL	Type of energy used for cooling, A(4).

PURPOSE: This card answers the question, "Does the production facility have the capability to substitute one form of energy for another?"

FORMAT

1 - yes   0 - no

COL 1	PCLOL	Coal for oil, I(1).
COL 2	PELOL	Electricity for oil, I(1).
COL 3	PCLNG	Coal for natural gas, I(1).
COL 4	PELNG	Electricity for natural gas, I(1).
COL 5	POLNG	Oil for natural gas, I(1).

Figure 6. Climate and Substitution Data Cards

PURPOSE: This card provides the program with information about the number of gallons of diesel fuel available for transportation of goods.

FORMAT

COL 1-15	DIESEL	Quantity of diesel fuel available, F(15.1).

PURPOSE: This card provides the program with values for the arrays (dimensions, 1 to NUMMAT) RMINV and RMU. The second card must be repeated to account for each raw material (NUMMAT).

FORMAT

Card 1

COL 1- 4	NUMMAT	Number of different raw materials per product, I(4).

Card 2

COL 1-10	RMINV (I)	Raw material inventory at beginning of month, I(10).
COL 11-18	RMU (I)	Quantity of raw material requirements per product, F(8.4).

Figure 7. Transportation and Raw Material Data Cards

PURPOSE: This card provides the program with the number of raw material suppliers, and the quantity of each energy available; card two must be repeated for each supplier (NUMSVP).

FORMAT

Card 1

COL	1- 4	NUMSVP	Number of raw material suppliers, I(4).

Card 2

COL	1-15	SLP	Quantity of each fuel available to the supplier
	16-30	SNG	for production, 5 F(15.1).
	31-45	SOIL	
	46-60	SCOAL	
	61-75	SELECT	

Figure 8. Suppliers Data Card

PURPOSE: This card provides the program with the namer of the supplier, the quantity and percent of total output that the manufacturer orders, the transportation data: weight per unit, distance shipped, and method of shipment, and an assigned product code number. The second card simply contains normal production fuel requirements of the supplier.

FORMAT

Card 1

COL 1-16	SUP 1	Name of supplier, A(16).
	SUP 2	(Due to the character handling characteristics
	SUP 3	of FORTRAN, four variables must be used to
	SUP 4	contain a sixteen character name.)
COL 17-26	CAP	Quantity of manufacturer's orders from supplier, I(10).
COL 27-36	PRODWT	Weight of product ordered, F(10.2).
COL 37-46	AUDIST	Distance supplies must be transported, F(10.2).
COL 47-50	LTRANS	Method of transportation used, A(4).
COL 51-52	MPN	The product's code, I(2).
COL 53-56	PCO	Percent of supplier's output ordered, F(4.2).

Card 2

COL 1-15	RLP	Number of units (BTU) of each type of fuel
16-30	RNG	required for normal production of CAP units,
31-45	ROIL	5 F(15.1).
46-60	RCOAL	
61-75	RELECT	

Figure 9. Suppliers Plant Data Card

B. Flow Analysis

The FORTRAN computer program, which has been written by the author as an implementation of the analysis procedure, has the modular structure shown in Figure 10. The procedure, ESAP, controls the flow of the algorithm, receiving aid from the subroutines and functions. These subordinate routines are represented in Figure 10 as brackets internal to the ESAP procedure, the external bracket. Each one performs a specific task described in Figure 11, in the analysis when called by the controller, ESAP.

Flowcharts of ESAP are shown in Figures 12 and 13. The flowcharts describe the computerized analysis and flow of information through ESAP. Figure 12 describes the manufacturing phase of the program. In this phase ESAP first defines, then initializes, the data storage structures. It then reads the production statistics, plant information, normal energy requirements, and change in fuel available. Through the invoking of the routine FUELUN, individual fuel requirements for one unit of production are determined. A random variation in the change of fuel available is provided through the PVAR routine. The ENERGY routine is invoked to aid in fuel reduction due to climate control. Available fuels may further be reduced due to special energy requirements and equipment deterioration, as a result of increased down time. Possible fuel substitutions are then explored prior to calculations of the final quantities of fuel for production.

The production capacity, based on available energy, is then projected by the subroutine PROCDP using the fuel per unit requirements. Finally, the raw material requirements for the product are read. The number of

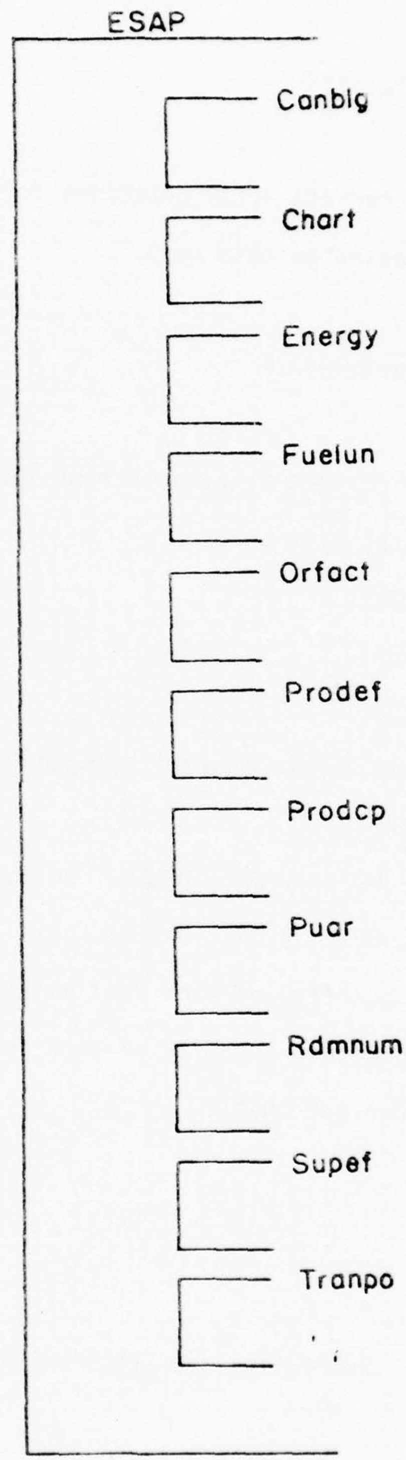


Figure 10. The Structure of ESAP

1. TRANPO - Function

   Input: LTRANS (character)

   Return: Integer

   Purpose: To return correct array subscript for the transportation mode indicated on data card.

2. ENERGY - Function

   Input: IFUEL (character)

   Return: Integer

   Purpose: To return correct array subscript for type of fuel indicated on data card.

3. RDMNUM - Subroutine

   Input: IX, IY (real)

   Return: YFL (real)

   Purpose: To generate random numbers between 0 and 1.

4. FUELUN - Subroutine

   Input: ULP, UNG, UOIL, UCOAL, UELECT, UNITS

   Return: ULP, UNG, UOIL, UCOAL, UELECT

   Purpose: To input quantity of each fuel necessary to product UNITS units and return quantity of each fuel necessary to manufacture one unit.

--continued

Figure 11. Subroutine and Function Descriptions

Figure 11. Subroutine and Function Descriptions, continued

5. PRODCP - Subroutine

   Input: BLP, BCOAL, BELECT, BOIL, BNG, ULP, UCOAL, UELECT, UOIL, UNG

   Return: FIN

   Purpose: To input quantity of each fuel available for production and fuel per unit of production requirements, and also, determine the limiting fuel quantity and return the production capacity based on fuel available.

The purpose of the following subordinate routines is to return real values from individual Monte Carlo tables, corresponding to integer value input.

6. CHART - Subroutine

   Input: PER (real)

7. PRODEF - Function

   Input: NPERD (integer)

8. SUPEF - Function

   Input: NPERD (integer)

9. CANBLG - Function

   Input: NPERD (integer)

10. ORFACT - Function

    Input: NPERD (integer)

11. PVAR - Function

    Input: IRN2

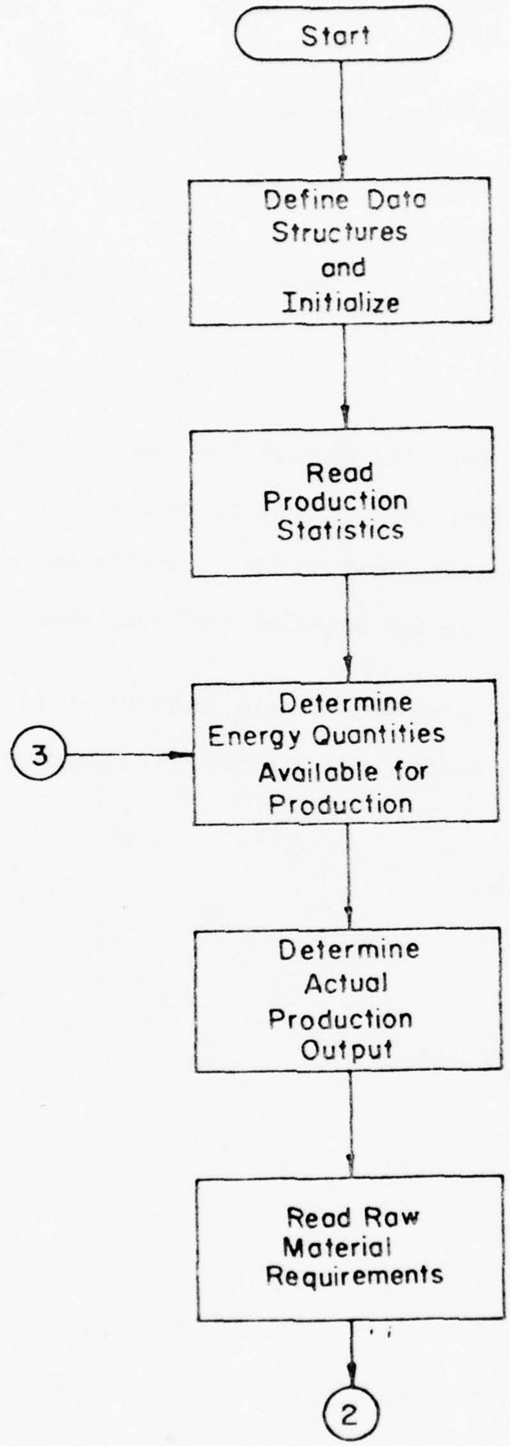


Figure 12. Flowchart of Manufacturing Phase of ESAP

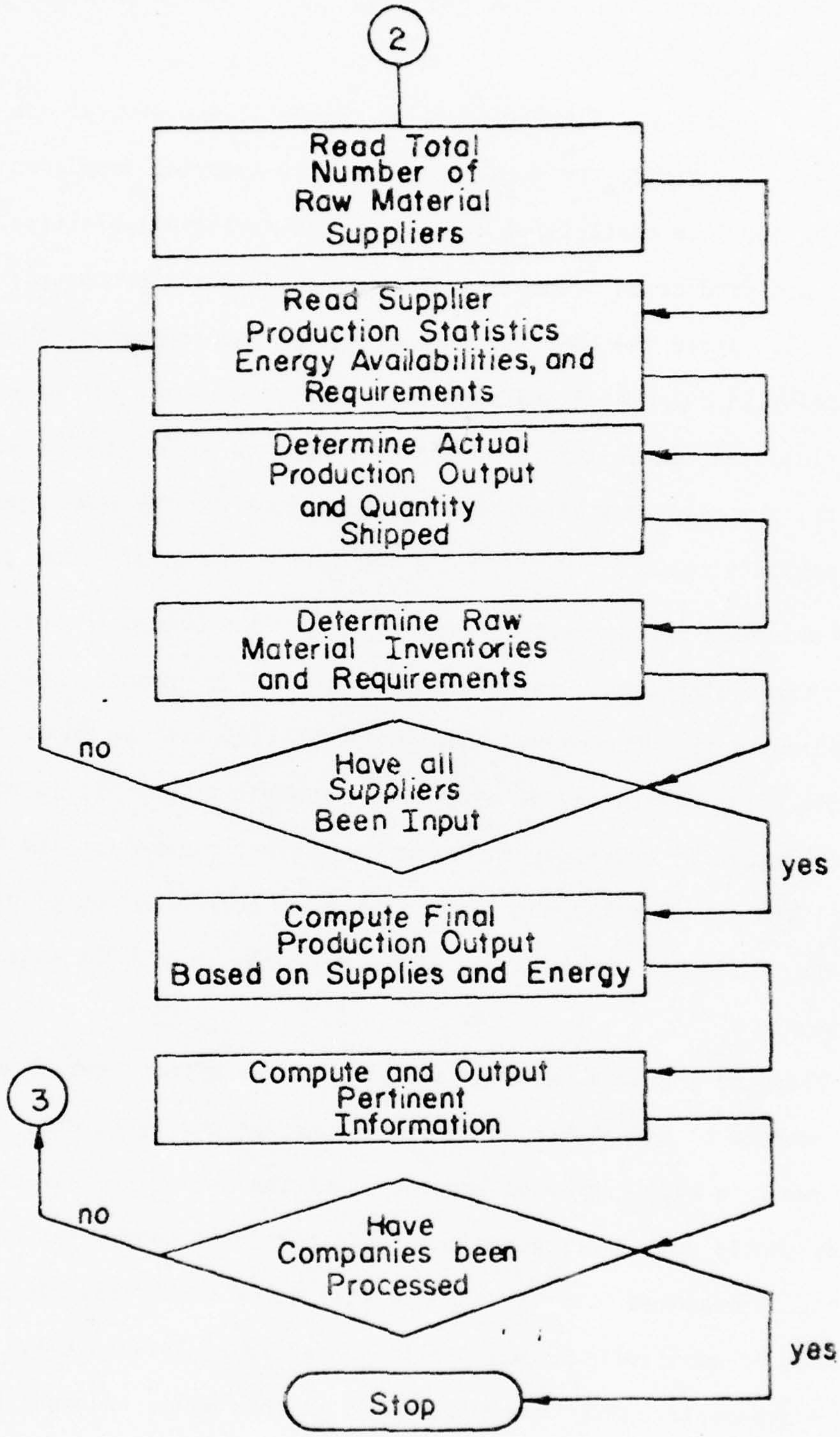


Figure 13. Flowchart of Supplier and Output Phases of ESAP

materials is then used to control the collection of data. Beginning raw material inventories and usage specifications are then obtained on an individual basis.

The supplier and final production phases of the program are described in Figure 13. First, the total number of raw material suppliers is read in, becoming the loop controlling variable. The fuel availabilities, requirements, and production statistics are then read in and processed, similar to Figure 12. After the supplier's final output is determined, the transportation delay is calculated and applied. Thus, having the raw material inventories updated, their impact on final production output can be calculated. Finally, the necessary statistics are generated for the next period while this period's results are output in the form shown in Appendix D.

The values for parameters were obtained from secondary sources and from interviewing companies participating in IPP programs. However, some parameters in the "Procedure" that are identified will be found to be relative while others may be outside a plausible range. It is realized that further design is necessary to determine whether parameters are statistically valid. The emphasis has not been on accuracy but rather on plausibility and what the system can teach in the kinds of things that might exist in the real world.

There is a general misunderstanding to the effect that an analysis or model cannot be undertaken until every constant and functional relationship is known to a high degree of accuracy; but the design and use of such techniques should not be postponed until all pertinent parameters have been accurately measured, because the day will never come. This leads to the omission of admittedly highly significant factors because these are unmeasured or unmeasureable. The "Procedure" used in this study is based on the best

information that is readily available. In some cases, values are estimated where necessary so that as many factors can be included and learned as possible. This is not to imply or discourage the proper use of data that is available nor the making of measurements.

Validation of Procedure

Validity of the Procedure, ultimate purpose, and the assumptions underlying the Procedure were not separated. The Procedure can only be expected to perform to the extent that the system has the characteristics to achieve the goals. In all cases, unknown and uncontrolled forces will develop that will cause events to occur which will affect the long-term outcome, and may or may not influence individual specific events at particular points of time.

The behavior of the Procedure is greatly changed if any of the controlling policies are changed. The use of quantitative techniques takes on authenticity; therefore, judgment must be a formal and sound part of the evaluation. Validation did not stop with numerical data but used both sources including *non-quantitative* areas.

SUMMARY

The "Procedure" is an information feedback system, not an open-ended model system in which results do not react on causes. Therefore, this presents controlled experiments and allows the observation of effects of separate segments of the system. The "Procedure" is based primarily on descriptive information available, statistical data, etc. Observation and familiarity reveal information sources that may not be obtained from historical

data. In the cases, these were included from the best available sources (mainly through interviews), and to omit them was considered a more serious failing than to have an error in magnitude.

The "Procedure" is designed to answer specific classes of questions. The completeness required depends on the questions to be explored. From utilizing the "Procedure," a more extensive estimate can be made of how much effort is justified in refining the system.

During development, considerable effort was made to carefully preserve essential characteristics in going from real life to the system. This involved using corresponding identifiable features and policies of the actual systems which required organization structure, amplification, delays, etc. Therefore, similar terminology, units of measure, concepts, objectives and goals were employed. To further insure realism, extensive interviews with managers of organizations having IPP programs were conducted.

The method was found to correspond to the important dynamic characteristics of industrial and managerial activity. Every attempt was made to make it simple and straightforward through a system of equations that individually evaluated successive time intervals in sequence of operations. Flow diagrams were developed simultaneously when formulating these equations. The flow diagrams represented the equations and the relationships within the system. This same characteristic was used for delays, the most simple representation.

Most important, the degree of confidence and acceptability of the overall system must be viewed and judged on the basis of usefulness over a given time period. Therefore, the procedure is not designed to predict specific events of particular unique behavior.

ANALYZING IPP PROGRAMS

Of the firms in the primary survey, only one, a major aircraft manufacturer, had an up-to-date Form DD 1519 and knew what was involved on the part of both the company and DOD. This firm was particularly interested in the program because it was a way of insuring and maintaining the Plant Equipment Package (PEP) that the firm had with DOD. In fact, the firm could not operate without using government-owned equipment under the PEP program. In other firms surveyed, the IPP forms were generally 4 to 5 years old and some even 9 to 10 years old with termination dates of 2 to 3 years later; thus, management considered they no longer had any commitment to DOD.

When these IPP programs were prepared, a considerable amount of effort was devoted to surveying the buildings and equipment. At the time, these forms reflected the firms' capabilities and abilities to meet the commitments. Today, the Forms DD 1519 are completely out-of-date and are useless, as firms have completely changed equipment, product lines, and technical knowledge. These changes have also involved discontinuing equipment, major expansions, and installing new automated equipment.

In this region, electricity is the major source of energy for many firms, with 3-phase motors and welding operations being very common. For this type of equipment it is necessary that voltage be maintained in the system; during "brownout" periods of reduced voltage, the firms cannot operate satisfactorily. If equipment is operated, immediate damage to electric motors occurs. Because of the critical shortage of natural gas, firms have developed standby sources of oil or LP gas to replace natural gas for heating, with many plants using their standby sources since October or November. However, no provision has been made for standby sources of electric power, which is essential to production.

A very inefficient use of energy is that most firms receive raw materials by truck and almost every plant ships its entire production to customers by truck.

Interestingly, suppliers are another very critical area that causes major problems for management when considering future production goals during an energy crisis. Management believes they could meet commitments if their suppliers would provide needed materials and parts. In all situations, management is concerned about the ability of their suppliers to meet requirements during an emergency. Some have requested them to prepare DD 1519 forms. Some have done so, but others have ignored them. In no cases have second-level suppliers been requested to prepare Form DD 1519.

Many firms have not had any communication with the Air Force/DOD since the initial agreement. This situation has caused management to feel no commitment to the Air Force/DOD, rather they are concerned only about their regular customers. Consequently, the present status of the IPP programs has caused most managers to be unsure about the preparedness of the nation's defense system, as management feels the Air Force/DOD are unconcerned about IPP programs. The present dilemma is that IPP programs are prepared between the DOD and the company, then management never hears from anyone concerning the program to update the Form DD 1519 and incorporate changes. As one manager stated, it seems "they" have a complete lack of interest concerning IPP programs.

In surveying the firms participating in IPP programs in this region, it is interesting to note that many firms that have efficient modern production facilities are not included in the program. This is another indication that IPP programs are badly in need of attention.

EFFECTS OF ENERGY REDUCTION ON IPP PARTICIPATING PLANTS

Using the ESAP, various programs of energy shortages were analyzed assuming different reductions for different types of energy. The following are highlights of the results; however, many other combinations could have been analyzed and developed into important policies for both industry and government if time had allowed.

The following sample cases provide background information and results of typical firms involved in the study. The information must be interpreted as a range rather than an exact value. Management was amazed at the magnitude of the results at first, but after the initial shock, management realized the problem and generally agreed with the results.

Case A - 10% Reduction in Natural Gas

This plant is a division of a major national company producing a wide variety of products for industry. The plant produces brake drums for heavy-duty trucks and trailers, suspension systems for tractor-trailers, and related product lines. Therefore, the Form DD 1519 is for these items. It has been approximately six years since the first contact was made with the company and no communication has occurred since the agreement was completed by the two parties. Unfortunately, there were misrepresentations in this situation, as the official representing DOD stated that if they would cooperate and prepare the Form DD 1519 it would mean added sales and some large future orders. This has never occurred; therefore management feels misled and does not have the best attitude toward DOD. Yet, this plant is very efficient and management is very successful, and it is a group that DOD would want and need in case of emergency.

During the past few years this plant has undergone several major production changes that have increased overall efficiency; however, pollution control equipment has been installed which has reduced production efficiency for some operations. New equipment has been mainly for production operations other than the product lines requested in the Form DD 1519, and the pollution control equipment has been for the operation producing the DOD product request. Consequently, there have been major changes in the plant's production capacity since the IPP agreement.

The major raw materials, such as steel and cast iron scrap, are obtained locally. A considerable amount of natural gas plus electricity is used in the manufacturing process. In this plant, a 10% reduction of natural gas caused serious problems for production, even though the firm's suppliers were able to meet raw material requirements as ordered. This is interesting because the firm requires five major raw materials which are obtained from a number of suppliers.

To meet IPP requirements, the firm could not ship any products to their regular customers for several months when shipping for the IPP commitment (Figures 14, 15, 16), and the firm could not even meet IPP requirements for several months during the period. The practice of not shipping to their regular customers is probably an unrealistic situation unless a national emergency occurs.

Case B - 40% Reduction in Natural Gas

This plant manufactures a wide assortment of coats; therefore, Form DD 1519 is for a number of military coats accounting for approximately 50% of the plant's production. This is one of the most modern plants of its type in the area, as it was constructed only 4 years ago. When the agreement was first initiated, a complete survey was conducted of buildings and equipment as they were at the time. The last Form DD 1519 was renewed in February

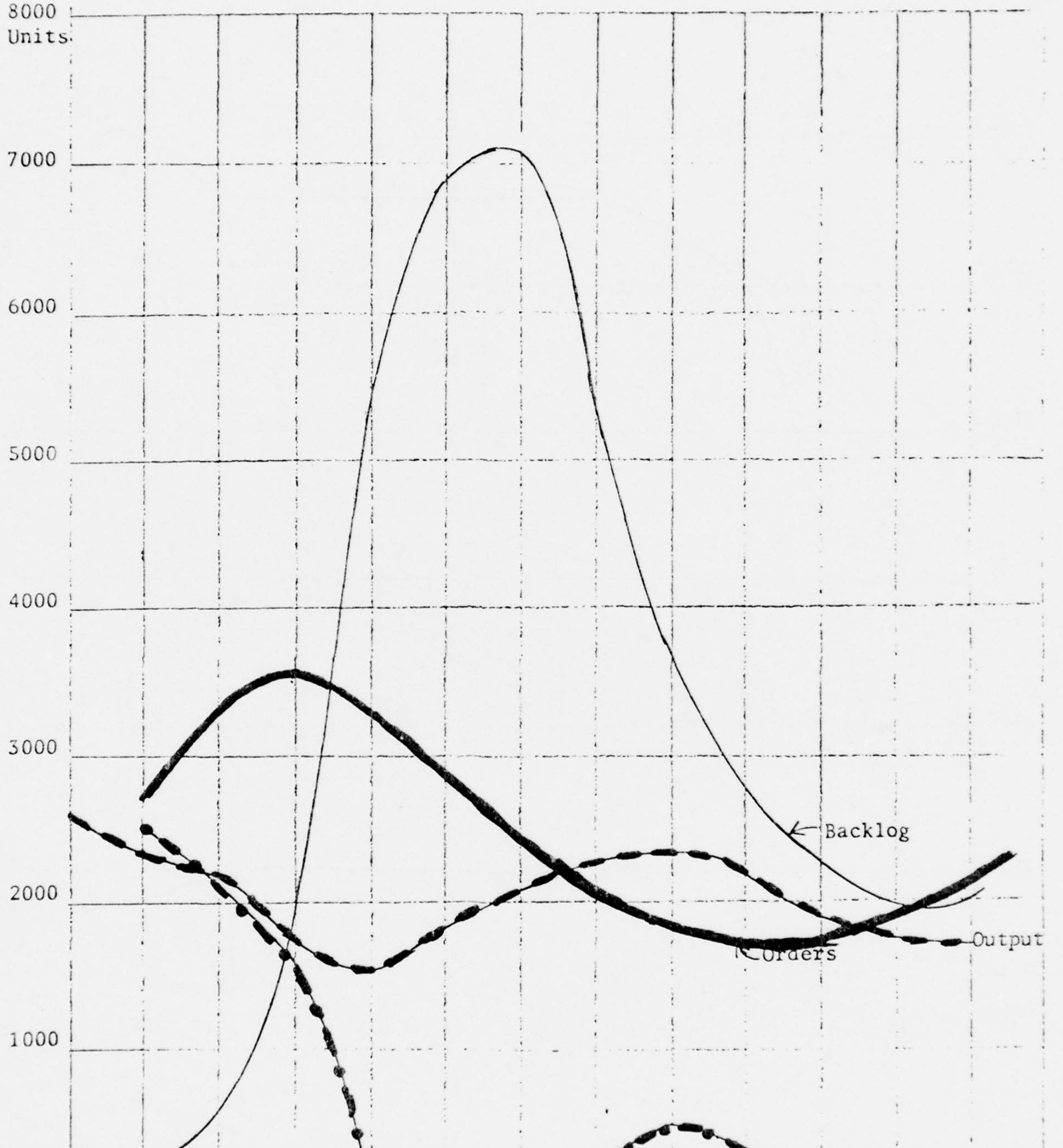


Figure 14. Case A - 10% Reduction of Natural Gas

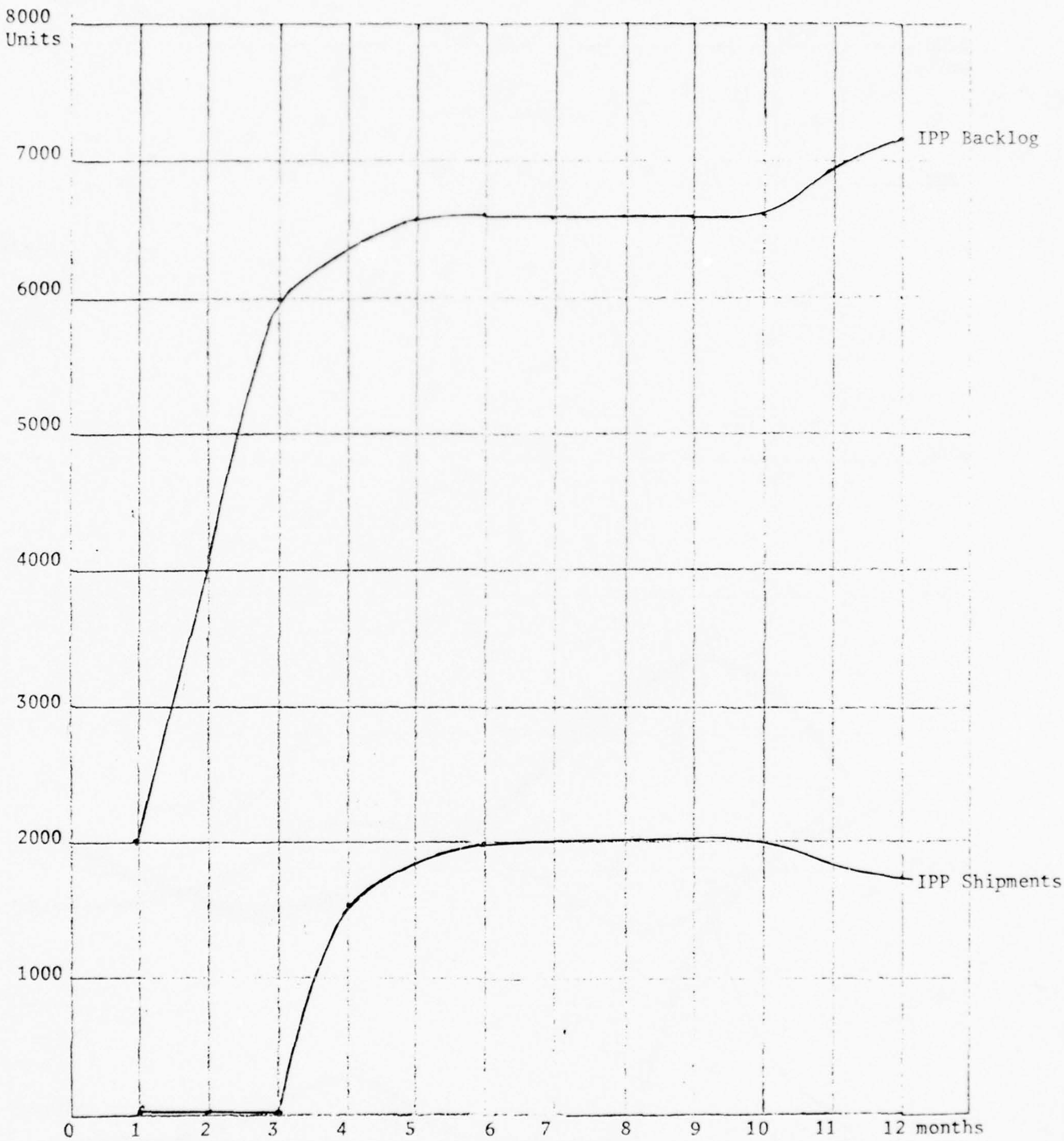


Figure 15. Case A - 10% Reduction in Natural Gas

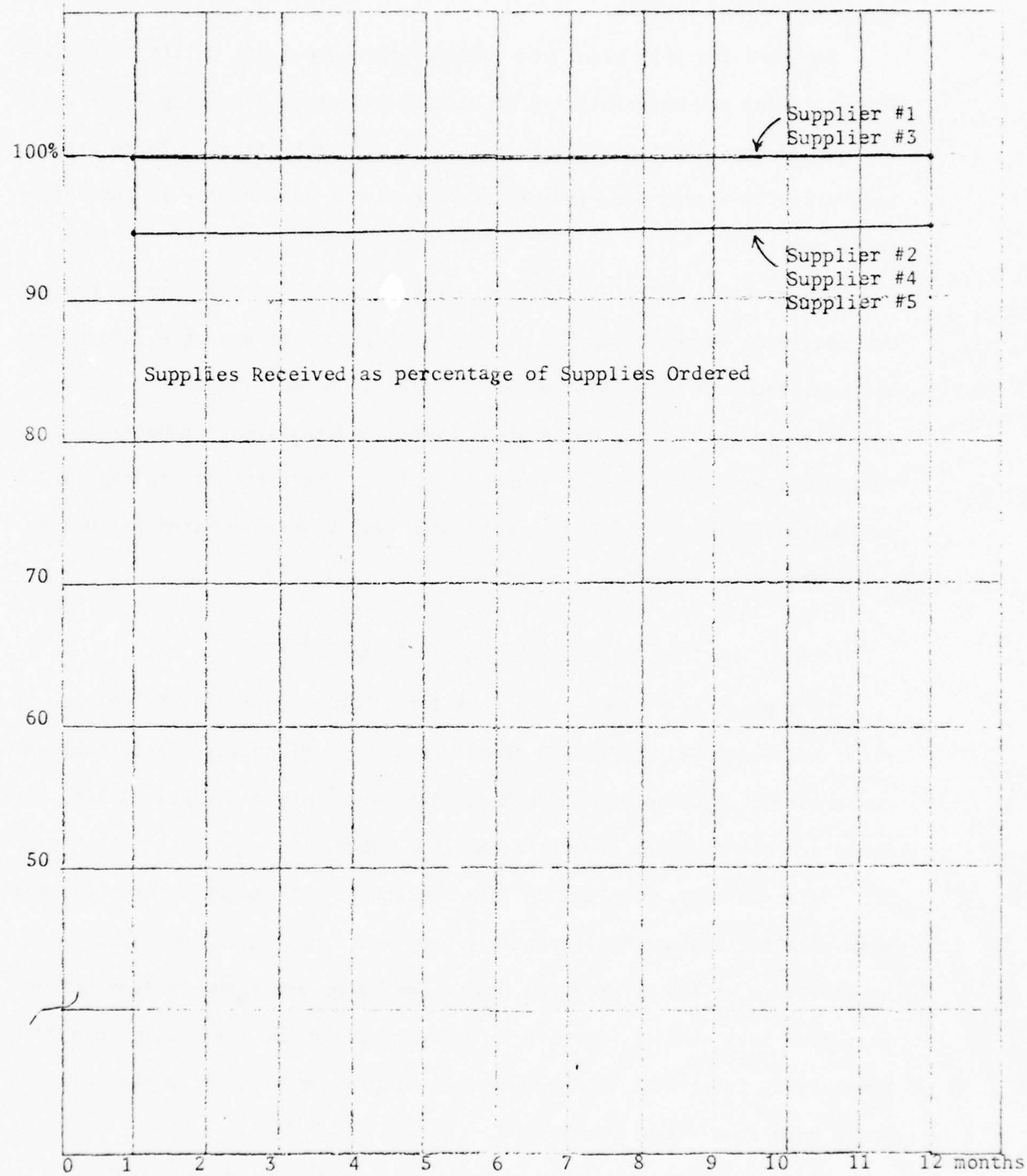


Figure 16. Case A - 10% Reduction in Natural Gas Supplies

1976, but no survey of facilities was made. Only one individual in the organization is responsible for the IPP program, is interested, and has knowledge of the program.

Supplies for this plant are obtained throughout the United States and Europe. Many raw materials are of the man-made type requiring large volumes of energy. Most of the raw materials arrive by truck. There are no high priority energy requirements for the plant; electricity is the main power source.

The greatest effect of reduced energy supplies on the plant's production was obtaining adequate supplies. This is because the man-made fibers used are made from raw materials having a petroleum base. Therefore, a 40% reduction in natural gas had a great effect on the firm's production capacity to produce expected output (Figures 17-18). The shipments to regular customers after making IPP shipments were almost zero compared to volumes being presently shipped to customers.

Case C - 15% Reduction in Electricity

This plant is a sheet metal fabricator having considerable volume. The plant was destroyed by fire 10 years ago and new production facilities were constructed. Because of the product characteristics and the location, most processes are designed to utilize maximum labor.

Unfortunately, the Form DD 1519 could not be immediately located, and when obtained had not been updated or renewed since 1969. Management had no knowledge of the IPP program, which had to be explained to them before they even knew what was involved. However, after the session, management became very interested in redeveloping the program if some initial effort would come from the Air Force/DOD.

The major energy requirement is electricity, and raw materials are obtained in the region and transported to the plant by rail and truck.

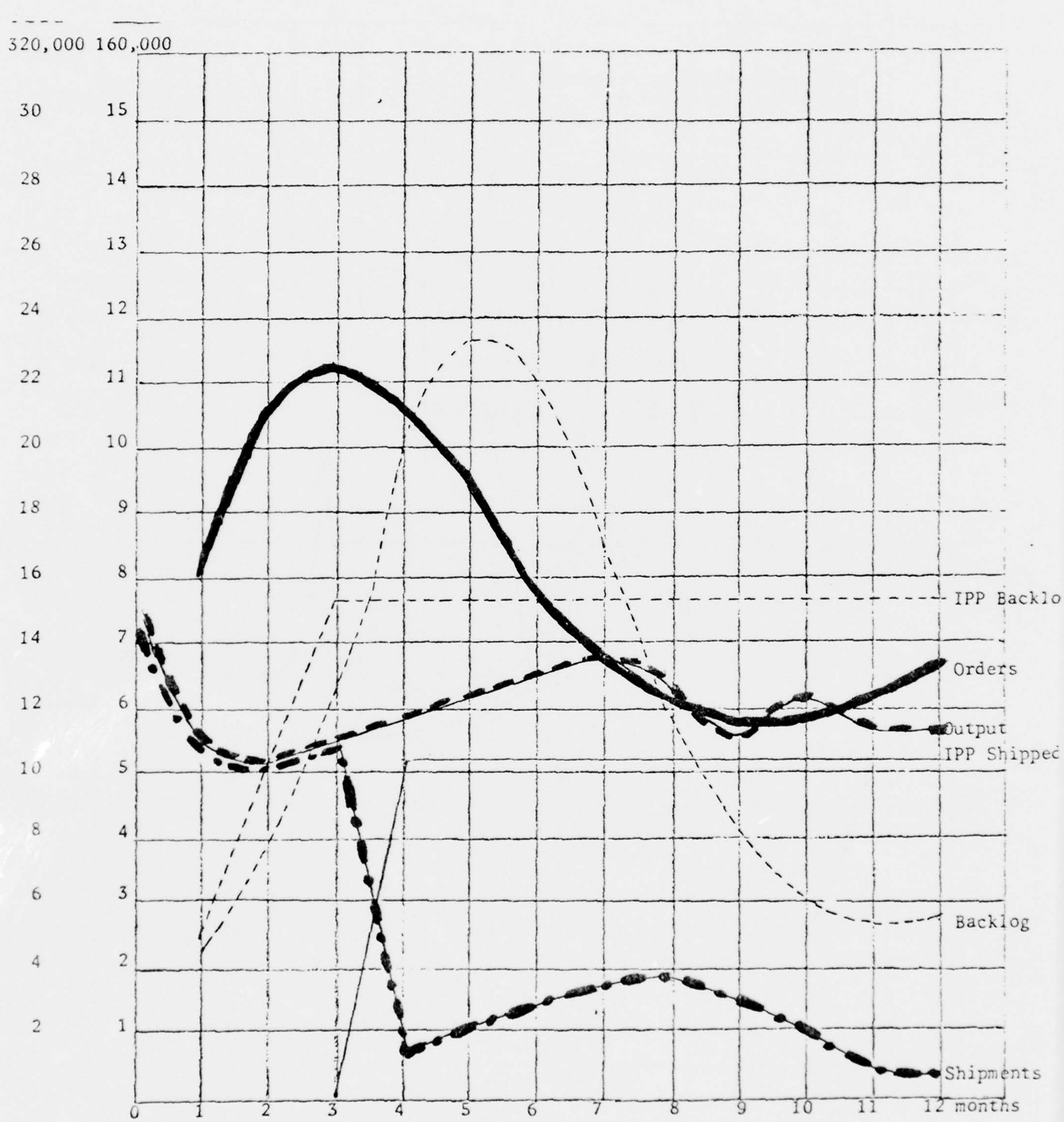


Figure 17. Case B - 40% Reduction of Natural Gas for Plant

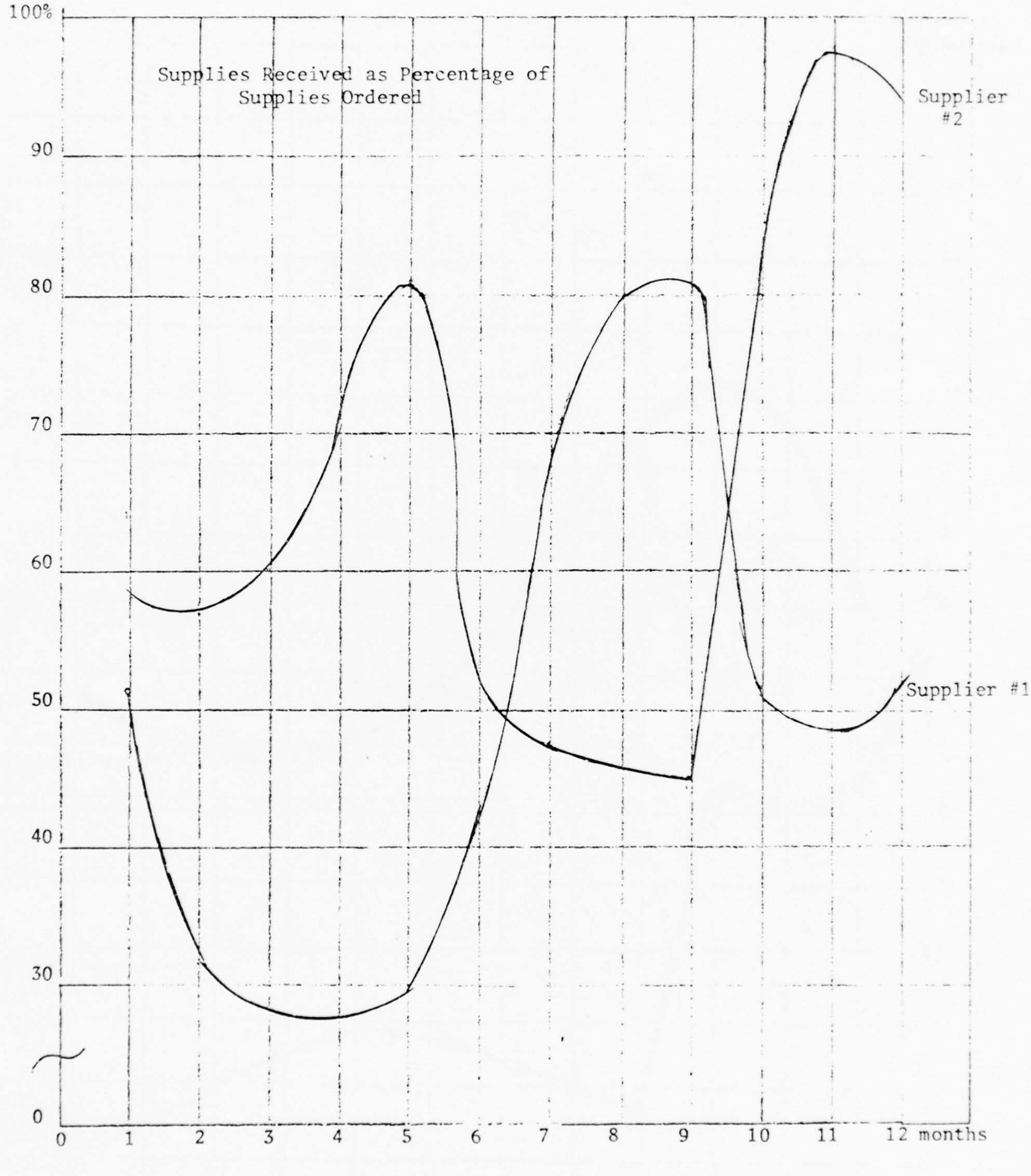


Figure 18. Case B - 40% Reduction of Natural Gas for Suppliers

A 15% reduction in KWH had minimal effect on production output for this plant (Figs. 19 and 20). However, the major supplier of steel, which is the only steel supplier, has a great influence on the firm's production. This is illustrated in Fig. 20 where at times the plant would only obtain between 50 and 65% of purchase requests (orders). This illustrates the importance of suppliers to any production operation; no plant is self-sufficient.

Case D - 25% Reduction in Natural Gas

The agreement with this plant to supply specialized cable was entered into in 1968 (to be terminated in 1970). No other communication has occurred between the plant representative and the Air Force/DOD. Since this time, major changes have been made in the production facilities; in fact, one important production process has been discontinued that was necessary for production of the Form DD 1519 requests. Management expressly stated that first, they do not have any commitment to the IPP program, and second, they could not even meet the Form DD 1519 request unless basic production equipment was obtained. With present production facilities, this product cannot be produced in the plant.

The most important source of energy in this plant is electricity, with all electrical equipment being 3-phase. A large number of different types of raw materials are required--aluminum, steel, paper, copper, and plastics. These are obtained throughout the United States and shipped into the plant by rail and truck.

The fact that this plant is highly dependent on supplies produced throughout the United States creates problems in meeting production goals. Two reasons are (1) the type of supplies required which demand large volumes of energy during production, and (2) the transportation method used and the distance.

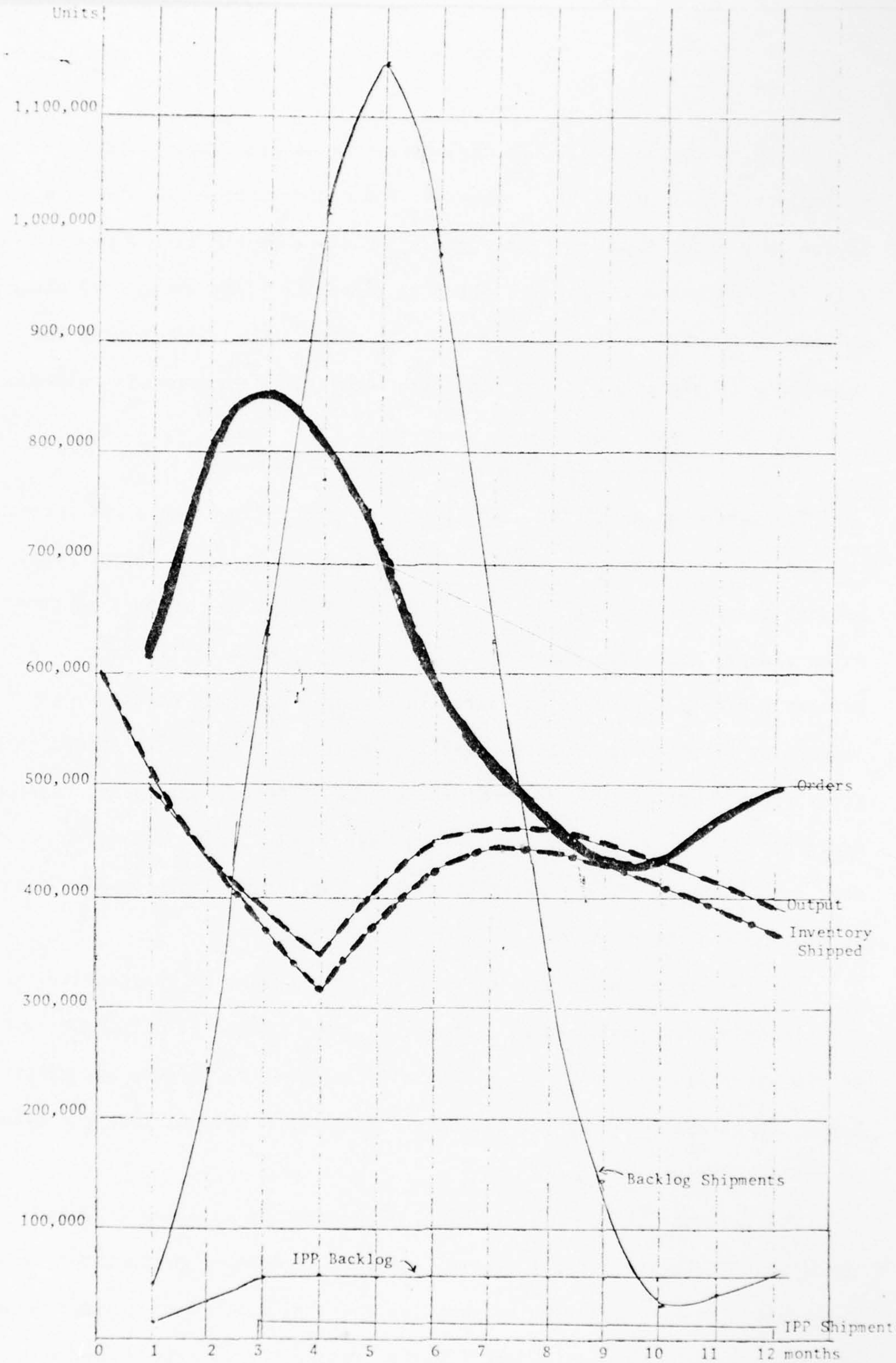


Figure 19. Case C - 15% Reduction of KWH for Plant

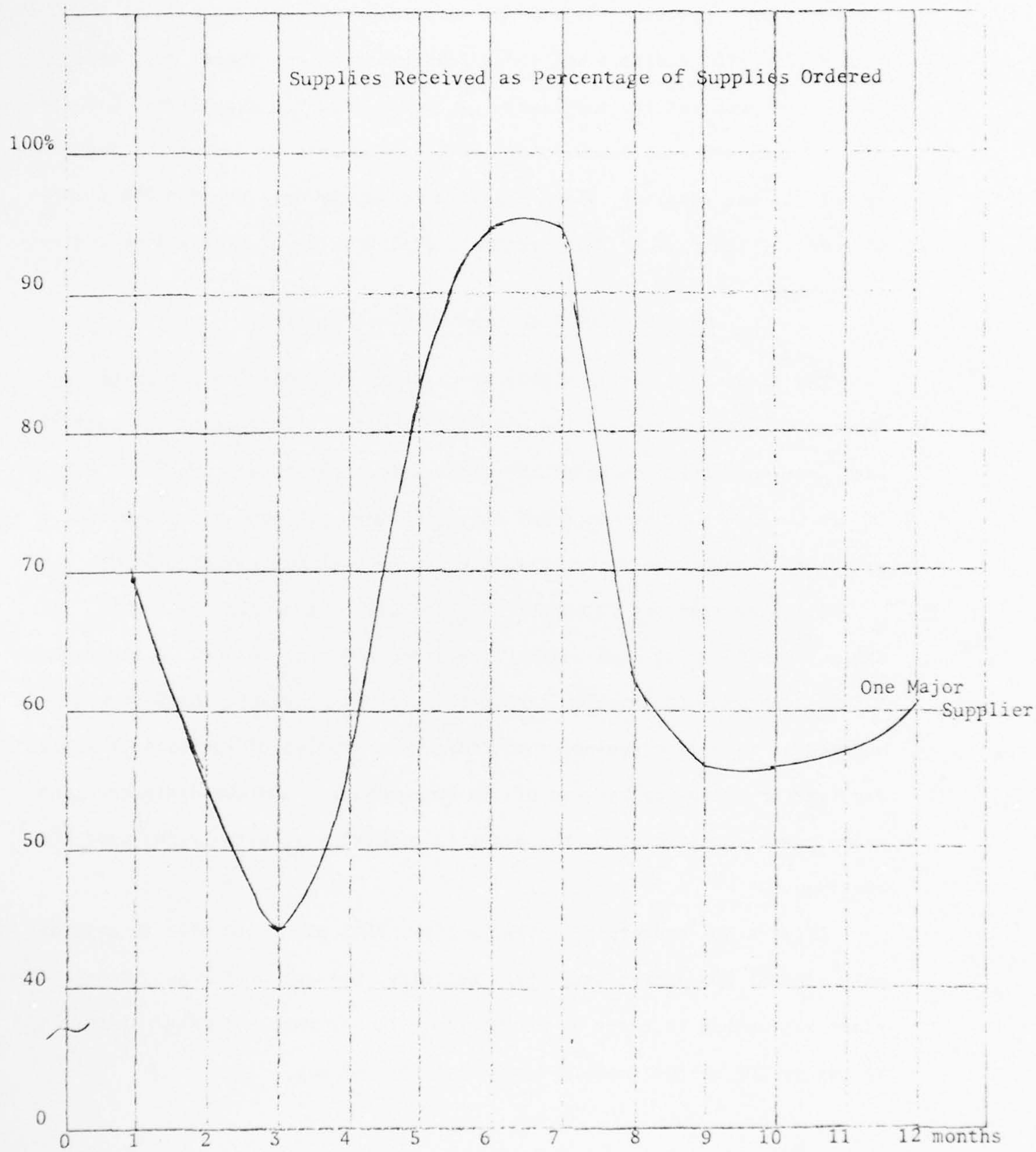


Figure 20. Case C - 15% reduction of KWH for Suppliers

Since the Form DD 1519 requested only a small volume of the plant's output and the item could not be produced, IPP requests were omitted from the analysis. However, the ESAP provided some interesting results (Figures 21 and 22). The analysis was for a 25% reduction in natural gas, causing production problems for suppliers. At first, several suppliers could not ship volumes ordered; however, orders and shipments eventually became close except for one supplier, which was able to supply only between 25% to 55% of orders (Figure 11). This created a real backlog of orders from customers.

Case E - 30% Reduction in Electricity

The plant is a small, highly specialized machine shop producing high precision parts mainly for the aircraft industry. This plant was contacted last year concerning changes that might affect the request on Form DD 1519. It is obvious that the form had initially been prepared and given considerable thought and actively maintained by both management and DOD.

All materials are transported in and out of the plant by truck. The raw materials are of high quality steel and are not produced in the region but are obtained at considerable distance from the plant. Consequently, management is very concerned about adequate supplies of raw materials during any type of emergency because of the type required and the distance. The major power requirement of the plant is electricity, with LP gas used for heating.

After a 30% reduction in electricity, this plant was able to maintain only minimal production activity. Actually, for all practical purposes, the plant was unable to carry on production. It was unable to make shipments to either IPP or customers (Figures 23, 24, and 25).

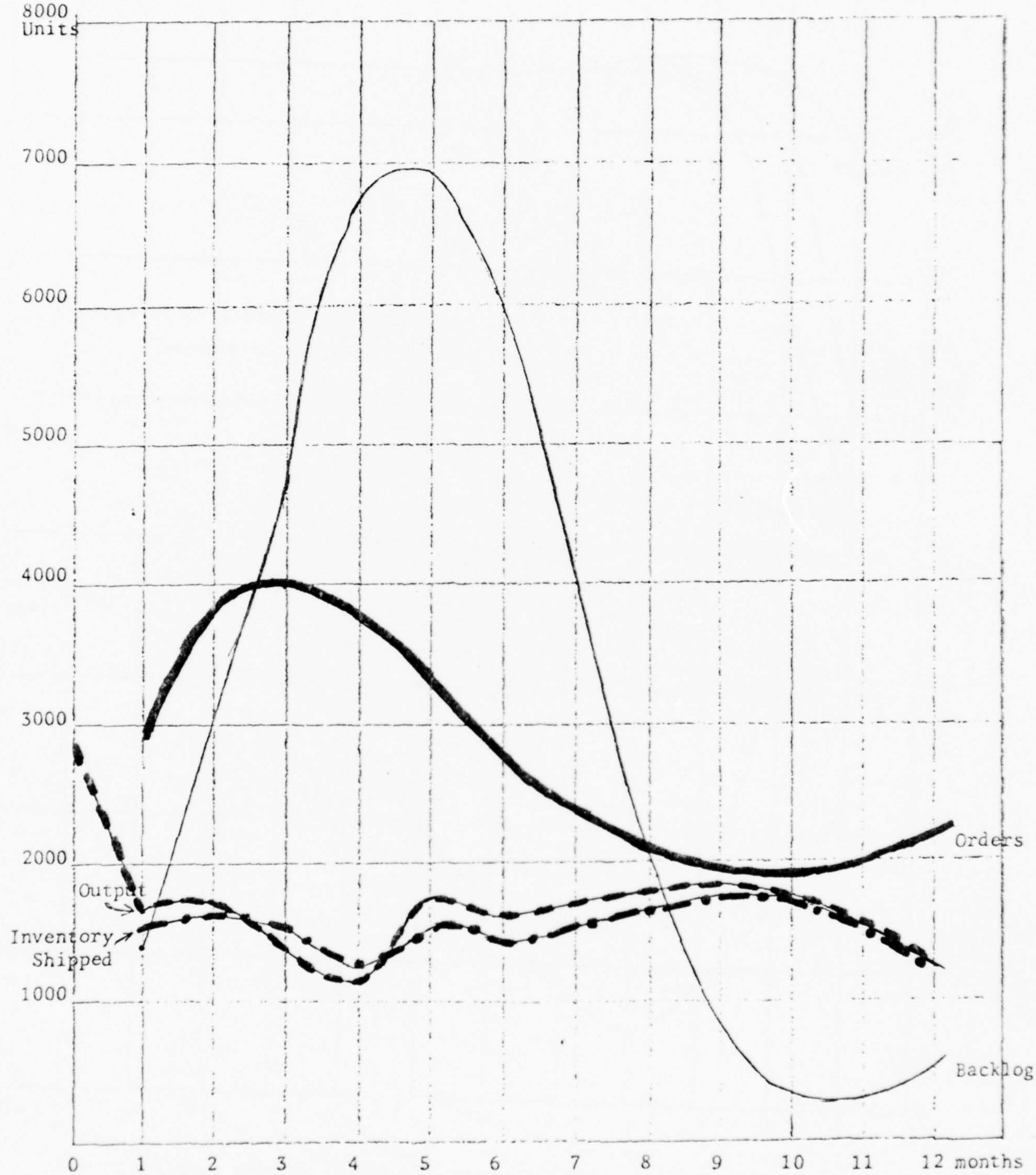


Figure 21. Case D - 25% Reduction of Natural Gas for Plant

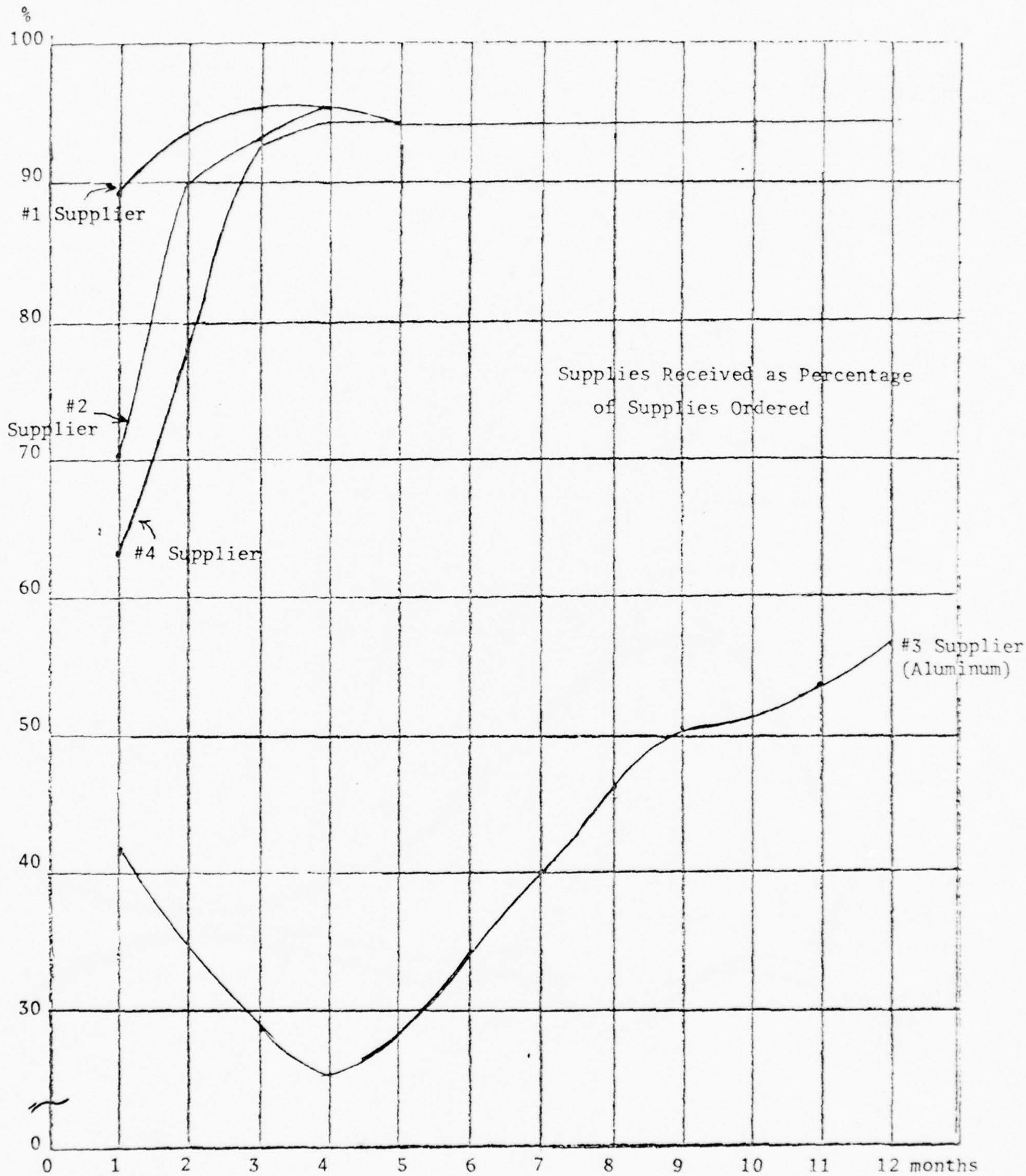


Figure 22. Case D - 25% Reduction of Natural Gas for Suppliers

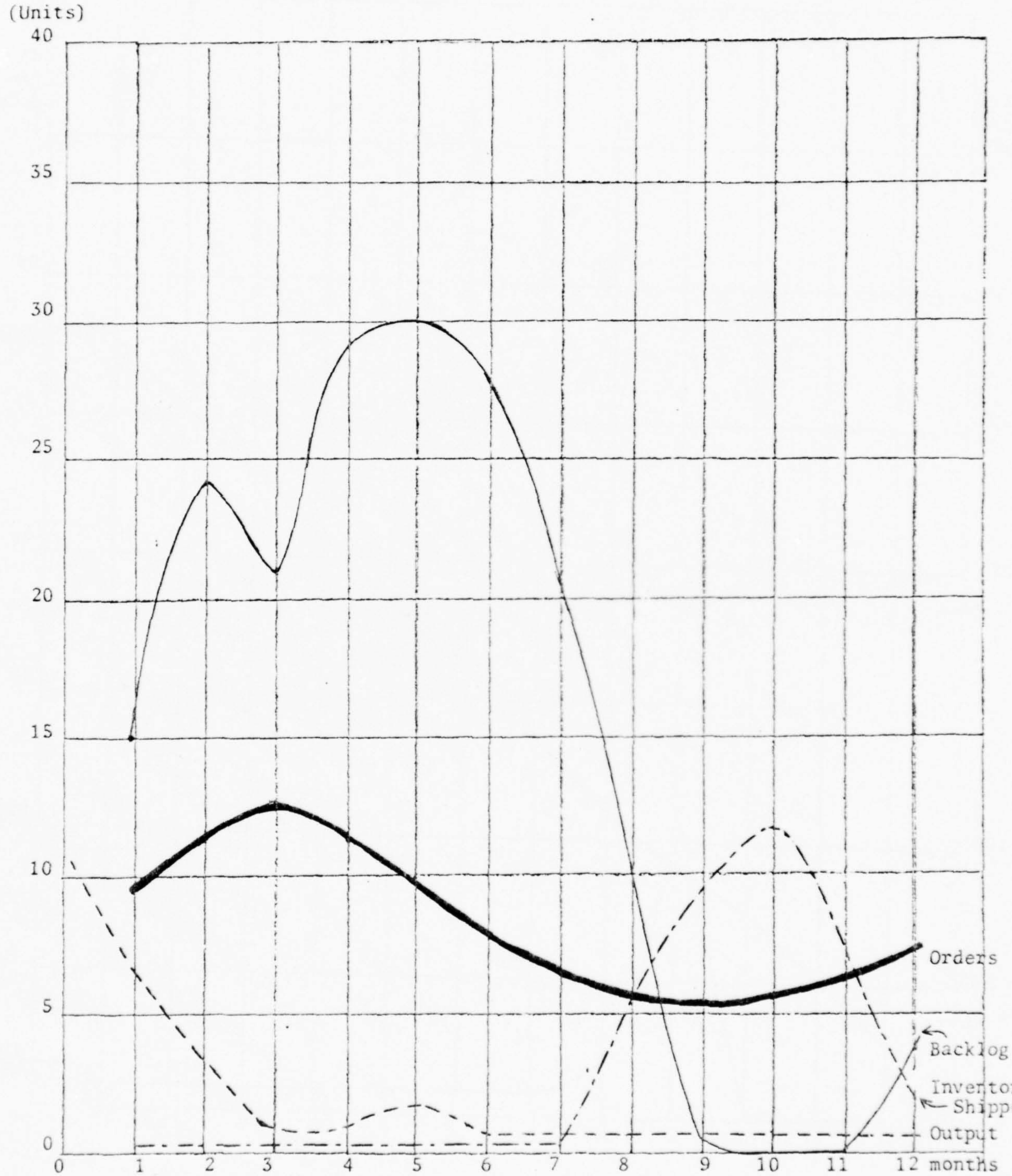


Figure 23. Case E - 30% Reduction of Electricity for Plant

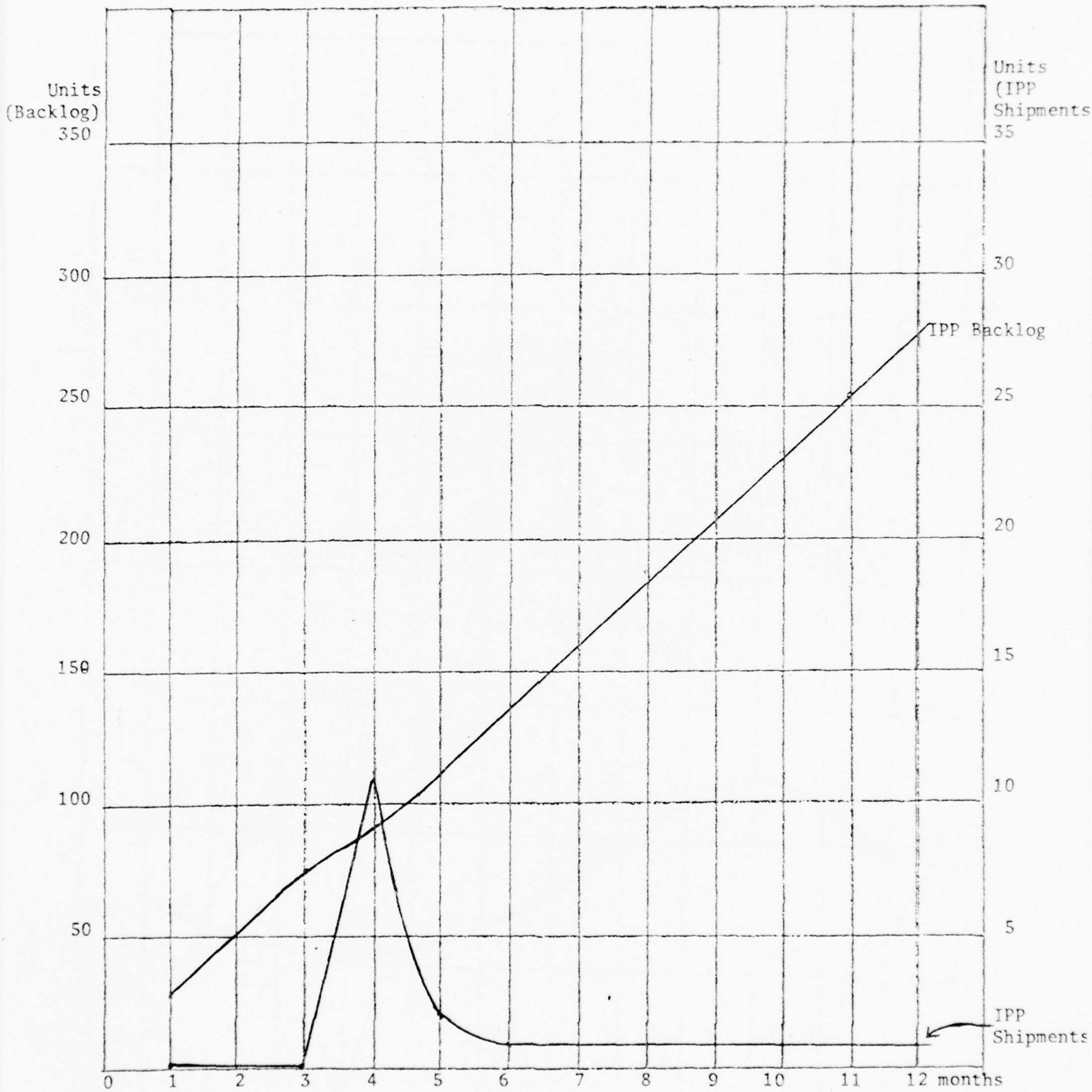


Figure 24. Case E - 30% Reduction of Electricity for IPP

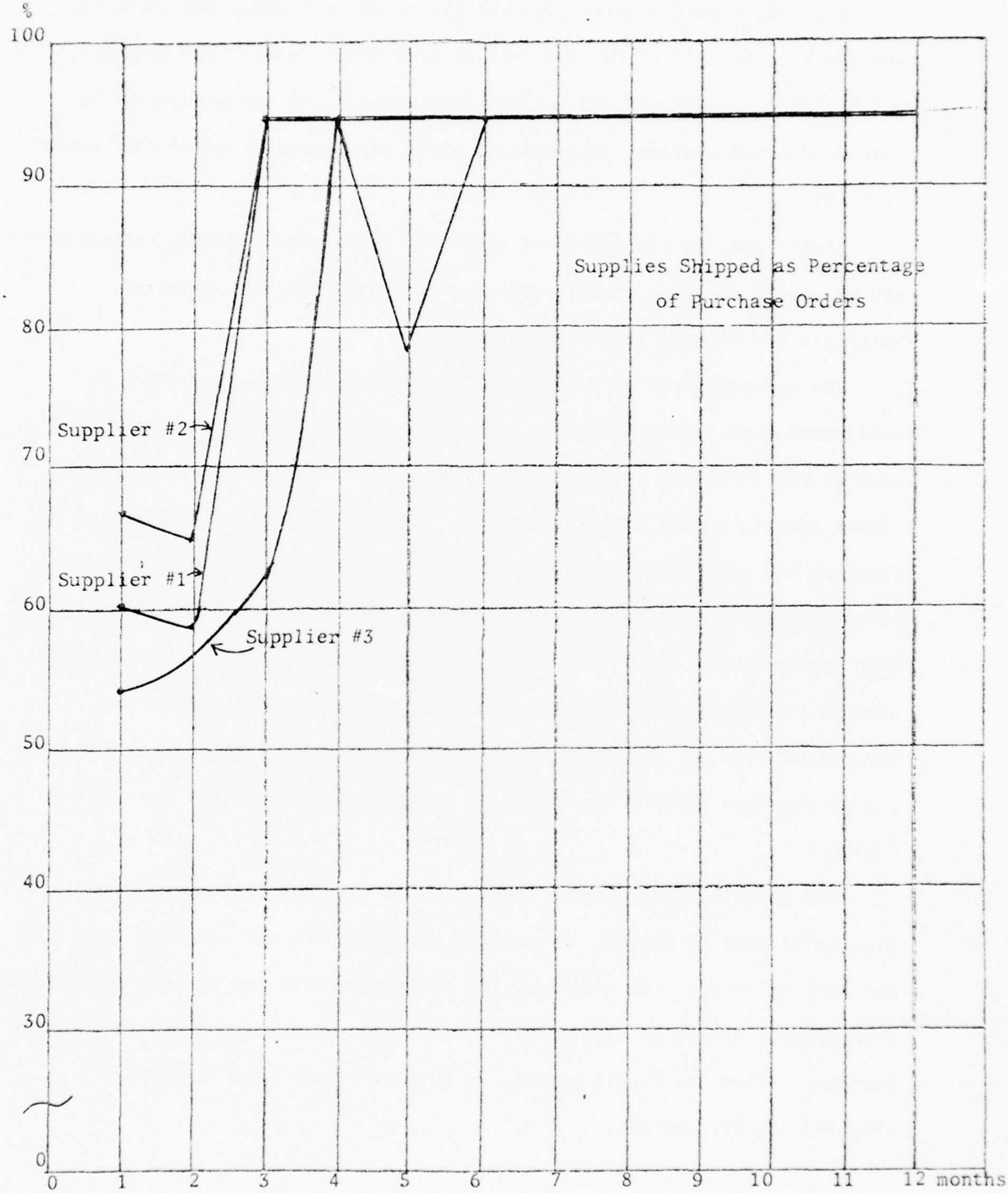


Figure 25. Case F - 30% Reduction of Electricity for Suppliers

Case F - 30% Reduction in Electricity

This plant manufactures high quality production tools for industry, and the Form DD 1519 is for specialized production tools. The request was prepared 8 years ago and has not been updated; to the manager it is out-of-date and useless, just another piece of government paper for someone to handle.

Electricity is the source of power for production. Heating requirements are met by LP gas plus a small amount of oil used for heat treating. Materials are shipped in and out by truck.

The management is very concerned about the problems they would be confronted with during an energy crisis, for the following reasons: First, electricity is a very critical power requirement and the plant equipment cannot operate during brownout periods. Second, this plant is supplied by firms on the east coast and overseas. Third, supplies used by this plant involve large volumes of energy during their production and are obtained from regions where even today there is a shortage of energy. Fourth, this plant's requirements are a small volume of the suppliers' production; because of this and the great distance, management believes that during an energy shortage their orders would be ignored or would be the last to be filled.

The plant's reaction to a 30% reduction in electrical energy was similar to that of Case E. Production was insignificant compared to orders and backlog orders. In addition, IPP shipments could not be made on schedule. Even after a period of adjustment to energy reduction, the output declined further. After the fourth period, no shipments were made to customers (Figures 26, 27, and 28).

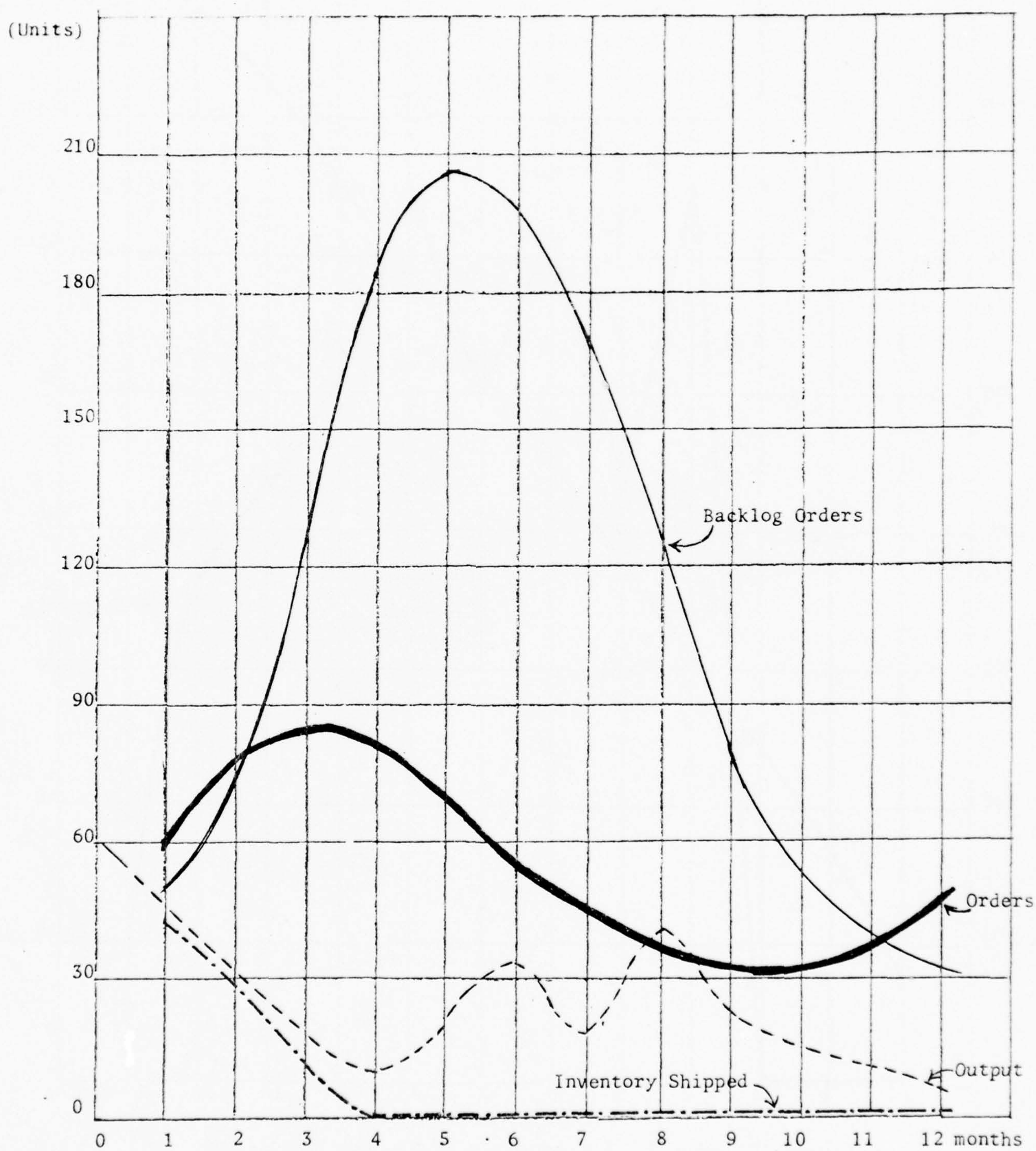


Figure 26. Case F - 30% Reduction in Electricity for Plant

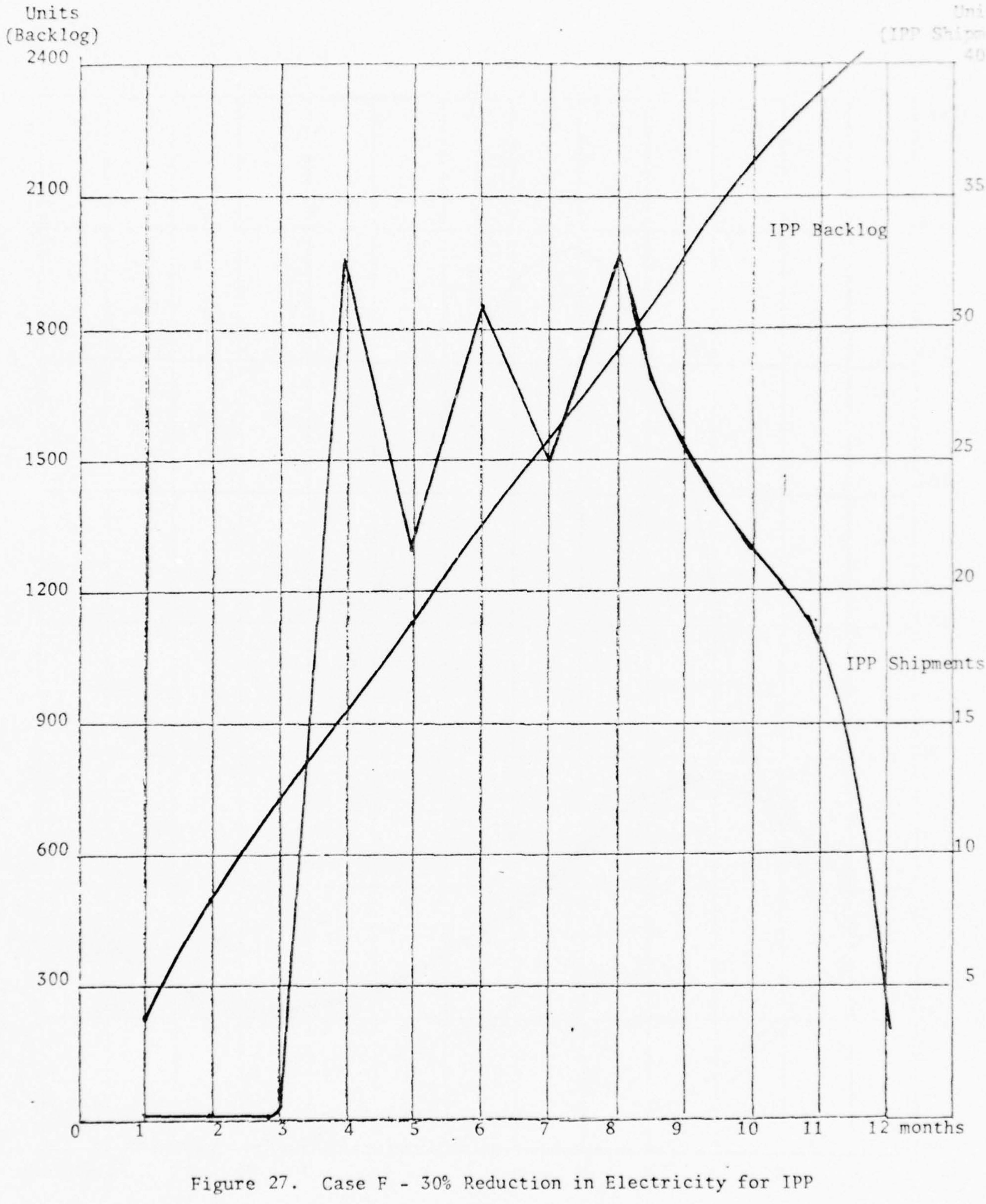


Figure 27. Case F - 30% Reduction in Electricity for IPP

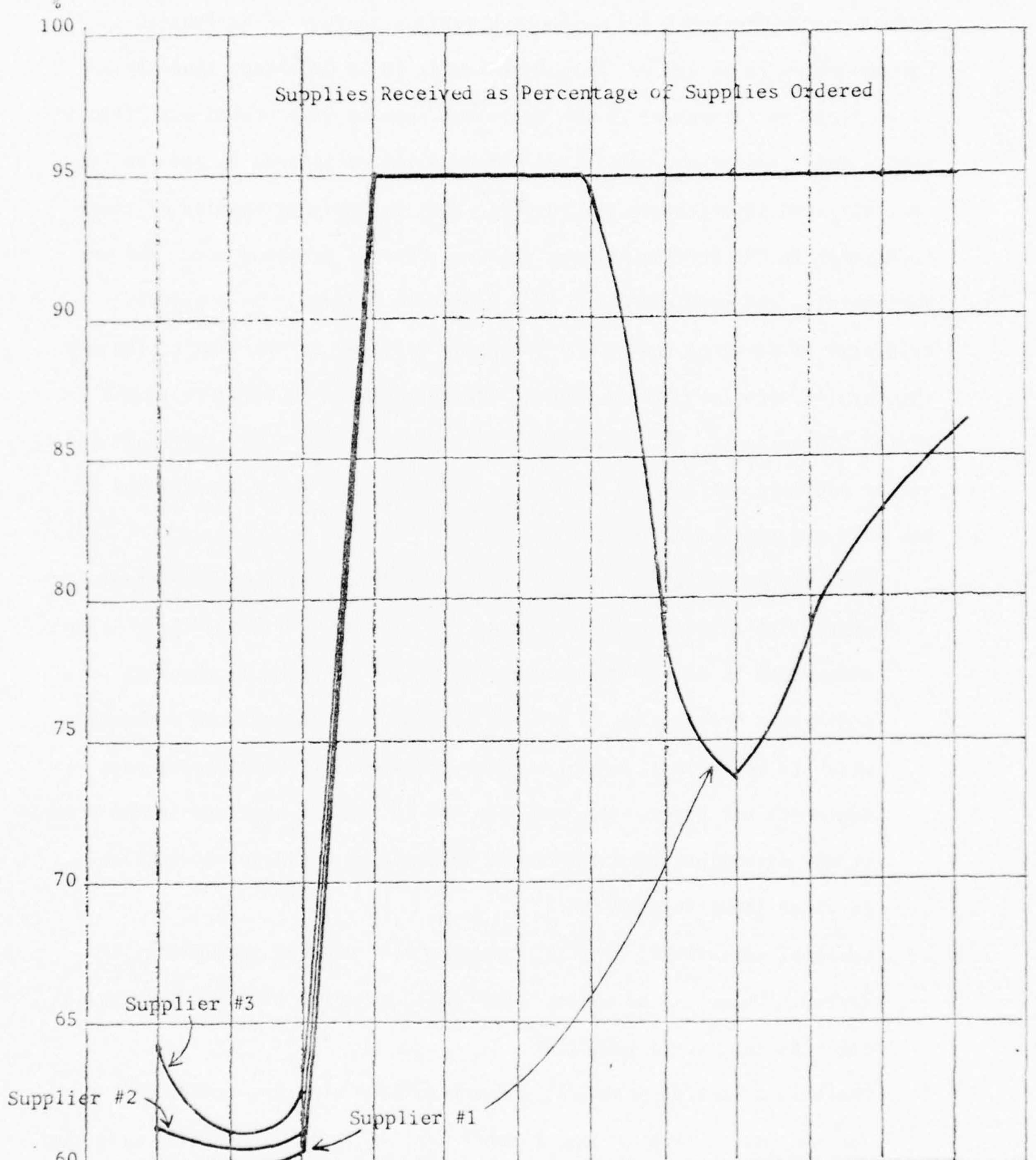


Figure 28. Case F - 30% Reduction in Electricity for Suppliers

LIMITATIONS OF ESAP

All procedures, models, systems, etc., developed to cope with a given problem or to provide information have various degrees of limitations. Consequently, in utilizing these techniques, it is important that these limitations be recognized by the users and results interpreted with them in mind. When limitations are either unrecognized or ignored by the user in analyzing and interpreting the results, then in applying results of these techniques in the decision-making process, serious problems occur and unfortunately, the problems occur in a geometric fashion. As a result, criticism is directed toward the technique utilized rather than to the way the results were interpreted without evaluating them in relation to the stated limitations. It is essential that limitations be set forth and the reader and user realize the importance of them. The major limitations of the ESAP are summarized as follows:

1. The system developed for the project was deterministic, which does not permit the addition of data during the period. Certainly there are advantages to adding data during the period, because in the real world, additional information is constantly becoming available to management which is valuable in making current decisions and readjusting past decisions and plans. However, for the 12 periods utilized in the program, it was determined that additional information would not be available to alter input information.
2. Seasonal variations, cyclical changes, etc. are not included in the system. These can be added, which would make the analysis more realistic to real world conditions.
3. There is a lack of probability distributions utilized extensively in the system. A greater use of Monte Carlo distributions would make the output closer to actual real world events.

4. There is lack of adequate testing to validate the Procedure. Future testing needs to be accomplished, using various alternatives and combinations of energy reduction.

5. It must be recognized that data and information for the developing and testing of the Procedure was limited to a small number of IPP firms located in the Midwestern region of the United States.

CATEGORICAL FINDINGS

These findings are based on the Energy Systems Analysis Procedure (ESAP) of firms having IPP programs surveyed, ranging from light fabrication plants to basic production plants.

1. The critical factor causing reduced plant output is lack of materials from suppliers which require high energy usage in their production. From the analysis, one or two suppliers from distant regions (Northeastern U.S.) caused major reductions of output in these plants.

2. Plants have made provisions for standby energy sources for heating purposes; however, no standby is available for electrical power which is especially important to these plants since "brownouts" will cause real problems.

3. Results for the program are limited to a one-year analysis, because firms can make major changes beyond a year to cope with energy shortages.

4. IPP programs for most firms are out-of-date, as they have not been updated and reviewed periodically. Plants have added and dropped production facilities and changed technical know-how since IPP surveys were prepared.

5. Many new production facilities in the area are not involved in IPP programs.

6. Management of the firms with IPP programs feel that the Air Force/DOD lacks interest in these programs because of the poor communication with them; therefore, management does not feel any commitment to DOD requirements, only to their regular customers.
7. Management is very concerned about our national defense and feels immediate action must be taken, because at the present time no one knows the industry's strengths and weaknesses.
8. Energy is the most basic resource in our production system. Without adequate supplies of energy in our present highly technological system, production cannot be maintained.
9. When electrical power drops to around 20%, production must be stopped in most plants, especially those requiring precision welding, etc.

RECOMMENDED USES FOR THE ESAP IN AIR FORCE IPP PROGRAMS

1. Analysis of the effects of energy reduction on the firm's production capabilities in comparison to other firms in the industry.
2. Determination of which production facilities in the IPP program are utilizing energy most efficiently.
3. Provision of needed information for selecting production facilities for IPP programs.
4. Establishment of benchmarks measuring how production will be affected during energy reductions.
5. This analysis will give firms an idea of what factors will probably limit their production capabilities during various types of energy reductions. Then DOD may encourage firms either to prepare for alternative energy sources or drop non-cooperating firms from their IPP program.
6. Assistance in determining what DOD supplies will be in critical shortage and need to be stockpiled by DOD.

RECOMMENDATIONS FOR IMPROVING THE IPP PROGRAM

1. It has been amply demonstrated that society and industry have not yet adopted energy efficiency and conservation practices. However, the government cannot expect industry and society to practice energy conservation and reduction if it does not adopt such practices itself. The U.S. Air Force must make changes and show how these changes contribute to increased efficiency through the IPP program. The Air Force must take the leading role in this area, similar to the Space Technology program in which space technology has been adapted to commercial uses.
2. It is true that during World War II, U.S. industry was able to respond very quickly. This was due to several conditions that are not true today, such as:
   - A. Industry generally was a one-shift operation until World War II, when it just added additional shifts. Today, however, industry must routinely operate two or three shifts to obtain adequate returns on investment.
   - B. In many cases, industry was undercapitalized; by adding capital equipment, production output increased considerably. Today this is not the situation, as most industrial firms have adequate capital equipment.
   - C. During World War II, more efficient use of external resources was made, i.e., the transportation system. Today, industry already makes very efficient use of these systems, such as shipment by air freight for some critical supplies.

   The Air Force must obtain information concerning the effects of energy on IPP plants immediately, because industry is operating close to a margin which does not allow for major increases in either output or changes in product types, and industry is sensitive to changes, i.e., energy, to which it reacts immediately.

3. The ESAP provides a range of what Air Force planners can expect from various types of energy reduction; however, follow-up work needs to be done to make it closer to real-world conditions. Recommended changes include seasonal and cyclical variations and more probability distributions.
4. The ESAP should be performed for all Air Force IPP firms in a Federal Region to determine how energy reduction affects IPP plants in the region. Later, the Procedure would involve all Federal Regions having Air Force IPP plants, then later, all DOD facilities.
5. This Procedure should be employed to evaluate the effect of energy on all new proposed weapon systems. This would determine which IPP plants would be expected to experience production problems in meeting commitments.
6. Because production capabilities of IPP plants are changing through new equipment, more efficient energy utilization, new technology, raw materials, etc., the Procedure should be utilized each year when Form 1519 is prepared.
7. The situation requires a more active interest by the Air Force and DOD in IPP programs, for the following reasons:
   A. Many IPP programs are out-of-date, as they have not been reviewed for many years.
   B. Plants have changed production facilities and their technical know-how during the past 3-5 years or since an IPP survey was made.
   C. Many new efficient production facilities are not presently involved in IPP programs.
   D. Management of firms with IPP programs feel that the Air Force/DOD lacks interest in these programs - communication needs improving.

8. At present, IPP plants do not have an energy priority, even during an emergency. Therefore, the Air Force and DOD should work to enact an energy priority system for IPP plants in the U. S. allocation program.

RECOMMENDATIONS FOR IMPLEMENTING PROCEDURE

There are several acceptable alternative methods available in implementing the system, and each method has advantages and disadvantages. The recommended format for implementing the ESAP provides the most flexibility for further evaluation and making changes in the Procedure. The following format is recommended (Figure 29):

Phase 1. Re-evaluate Procedure and implement changes to avoid the major limitations in the present Procedure. These would include adding probability distributions to make the system reflect real world conditions more closely.

Phase 2. Perform additional testing of the procedure to validate the method. Data is now available from the 1976-77 energy crisis to test and complare output with actual events. This will provide an ideal comparison of activities of IPP plants with the ESAP output.

Phase 3. Gather case studies of firms and industries to obtain in-depth evaluation and comparison of both actual real-world results and ESAP results.

Phase 4. Utilize the ESAP to determine the effects of energy reduction on IPP plants producing materiel and components for U.S. Air Force weapon systems.

Phase 5. Utilize system for all U.S. Air Force IPP plants to determine the effects of energy reduction on their capabilities to produce committed U.S. Air Force materiel and components.

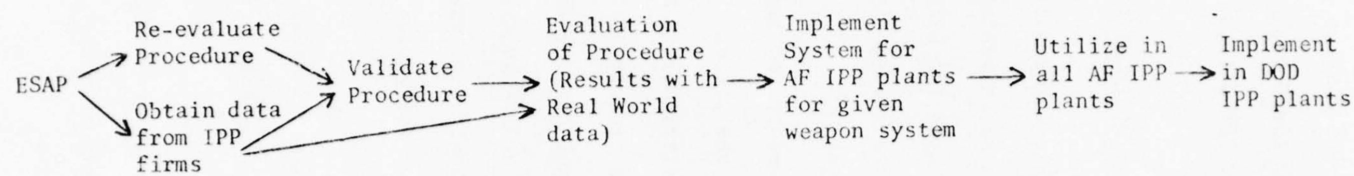


Figure 29. Diagram of Implementing Procedure.

Phase 6. Implement system throughout DOD network of IPP plants and for all new weapon systems proposed.

RECOMMENDATIONS FOR FUTURE STUDY

The ESAP provides information to determine the effects of energy reduction on EPP plants. With this information available to decision makers, goals can be established for energy conservation, energy recovery, alternative energy sources, raw material substitutes, and different products and processes. All of these are vital alternatives and must be considered to achieve the stated goals. Decision makers must know what effects energy reduction will have on production and on the IPP plants' suppliers. The ESAP provides information to decision makers of the type necessary to make feasible adjustments.

The following specific recommendations for further research are:

1. Re-evaluate and correct Procedure to avoid limitations noted previously.
2. Perform additional testing of the system using data from IPP plants in a given Federal Region and for a particular weapon system utilizing different combinations of possible energy reductions.

   This will first involve a case study approach of IPP firms and industry, comparing and evaluating past activities. In addition, inputs will be provided concerning various other aspects of the IPP plants and industry that may limit the firms' capabilities in responding to their commitments.

   One item that must be included in the Procedure is that certain minerals are becoming in short supply and thus might limit IPP plants' capabilities in making commitments. This may occur in the very near future and needs to be considered in the analysis. During this phase of the study, information can be obtained to include this in the Procedure.

3. Data from the IPP plants for a particular weapon system will be compared and evaluated with data from the 1976-77 energy crisis.
4. Evaluate Air Force/DOD policy for effectively and efficiently implementing system.

NOTES

[1]Federal Energy Administration, "Monthly Energy Review for July 1976," National Information Center, Washington D. C., July, 1976.

[2]Amalia Vellianitis-Fidas, "The Demand and Supply of World Petroleum and its Consequences for Agricultural Economic Development." Unpublished paper presented at the Third Annual UMR-MEC Energy Conference, Rolla, Missouri, October, 1976.

APPENDIX A

ENERGY SYSTEM ANALYSIS PROCEDURE

(ESAP)

COMPUTER PROGRAM

```
C
C
C      ****************************************************************
C      ****************************************************************
C
C
C         UNITS
C         COAL/TON , NGAS/CU.FT. , OIL/GALLON , ELECT/KWH , LP/GALLON
C
C         TIME PERIOD
C         ONE MONTH
C
C
C     *****     CARDS 0-4 & 5-9  INSERT FOR FIRST PERIOD ONLY      *****
C     *****     CARDS   10-13    INSERT FOR ALL TWELVE PERIODS     *****
C
C
C     CARD -1
C         NUMBER OF COMPANYS                                          I4
C     CARD 0
C         AMOUNT OF EACH FUEL AVAILABLE LAST PERIOD
C              (LP,NG,OIL,COAL,ELECT)                                 5F15.1
C     CARD 1
C         PRODUCTS SHIPPED LAST PERIOD                                I10
C         BACKLOG ON ORDERS LAST PERIOD                               I10
C         NUMBER OF PRODUCTS ORDERED TWO PERIODS AGC                  I10
C         NUMBER OF PRODUCTS ORDERED LAST PERIOD                      I10
C         NUMBER OF PRODUCTS COMMITED TO DOD PRODUCTION               I10
C         AVERAGE NUMBER OF PRODUCTS ORDERED EACH PERIOD              I10
C         AVERAGE DISTANCE PRODUCTS ARE SHIPPED                       I10
C         PRODUCTION CYCLE PERIOD                                     F5.3
C     CARD 2
C         NAME OF PRODUCT                                             A16
C         NUMBER OF UNITS NORMALLY PRODUCED (PER PERIOD)              I10
C         AVE. AGE OF PRODUCTION EQUIPMENT(YEARS)                     I2
C         SPECIAL FUEL REQUIRMENTS (LP,NG,OIL,COAL,ELECT)             5F9.1
C         TYPE OF TRANSPORTATION (AIRE,RAIL,TRUK,WATR)                A4
C     CARD 3
C         QUANTITY OF EACH FUEL CONSUMED (LP,NG,OIL,COAL,ELECT)       5F15.1
C     CARD 4
C         % CHANGE IN FUEL AVAILABLE (LP,NG,OIL,COAL,ELECT)           5F7.4
C     CARD 5
C         VOLUME OF PLANT (CU.FT.)                                    F15.1
C         TYPE OF FUEL USED FOR HEATING (NGAS,COAL,FOIL,ELET,LGAS)    A4
C     CARD 6
C         FUEL SUBSTITUTION POSSIBLE ( 1-YES,0-NO )                   5I1
C         (CLOL,ELOL,CLNG,ELNG,OLNG)
C     CARD 7
C         AMOUNT OF DIESEL FUEL AVAILABLE                             F15.1
C     CARD 8
C         NUMBER OF TYPES OF RAW MATERIALS                            I4
C
C     **  REPEAT CARD 9 FOR EACH TYPE OF RAW MATERIAL ACCOUNTED FOR ON CARD 8  **
C
C     CARD 9
C         RAW MATERIAL INVENTORY AT BEGINNING OF PERIOD               I10
```

```
              C           QUANTITY OF RAW MATERIAL USED TO PRODUCE ONE PRODUCT          F8.4
              C       CARD 10
              C           NUMBER OF SUPPLIER'S                                          I4
              C
              C       **  REPEAT CARDS 11,12 AND 13 FOR EACH COMPANY ACCOUNTED FOR ON CARD 10  **
              C
              C       CARD 11
              C           AMOUNT OF EACH FUEL AVAIL. - SUPPLIER(LP,NG,OIL,COAL,ELECT) 5F15.1
              C       CARD 12
              C           SUPPLIER'S NAME                                               A16
              C           NUMBER OF UNITS NORMALLY ORDERED FROM                         I10
              C           PRODUCT'S WEIGHT (#)                                          F10.2
              C           AVE. DISTANCE TRANSPORTED                                     F10.2
              C           METHOD OF TRANSPORTATION (AIRE,RAIL,TRUK,WATR)                A4
              C           PRODUCT CODE                                                  I2
              C           PERCENT OF SUPPLIERS OUTPUT ORDERED                           F4.2
              C       CARD 13
              C           QUANTITY OF EACH FUEL REQUIRED (BTU) (LP,NG,OIL,COAL,ELECT) 5F15.1
              C
              C       ***************************************************************
              C       ***************************************************************
              C
              C
0001                  REAL NGU
0002                  INTEGER ECAGE,UNITS,CAP,FINOUT,PCLOL,PELOL,PCLNG,PELNG,POLNG,
                     2   ORDERS,AVEORD,BLGSAL,DODCOM,DODSHP,BLGDOD,DIST,RMINV,RMUSE
0003                  DIMENSION TRANS(4),FUEL(6),RMINV(10),RMU(10),RMUSE(10)
0004                  DIMENSION ALP(15),ANG(15),AOIL(15),ACOAL(15),AELECT(15)
0005                  DIMENSION ORDERS(15),INVSHP(15),BLGSAL(15),DODSHP(15),BLGDOD(15)
0006                  DIMENSION SUPSHP(15),PURORD(15),UPUROR(15),PRDSHP(15),MRAND(15)
0007                  DATA IY/3843/
              C           FUEL / TON MILE      (AIR,RAIL,WATER,TRUCK)
0008                  DATA TRANS(1)/.195/,TRANS(2)/.005/,TRANS(3)/.017/,TRANS(4)/.005/
              C           BTU / UNIT FUEL      (COAL,NGAS,OIL,ELECT,LPGAS,BLANK)
0009                  DATA FUEL(1)/21230000.0/,FUEL(2)/1000.0/,FUEL(3)/138690.0/
0010                  DATA FUEL(4)/10500.0/,FUEL(5)/92000.0/,FUEL(6)/138690.0/
              C           BTU SUBSTITUTION RATIOS
0011                  DATA SRCLNG/.0000471/,SROLNG/.00721/,SRELNG/.09524/
0012                  DATA SRCLOL/.00653/,SRELOL/13.20857/
              C
              C
0013                  READ (5,560)  INONE
0014                  DO 2000  NUMCOM=1,INONE
              C
              C           DATA DIVISION
              C
0015                  EXNG = 0.0
0016                  EXOIL = 0.0
0017                  EXCOAL = 0.0
0018                  EXELCT = 0.0
0019                  CLOIL = 0.0
0020                  ELOIL = 0.0
0021                  CLNG = 0.0
0022                  ELNG = 0.0
0023                  OLNG = 0.0
0024                  REDLP = 0.0
```

```
0025          REDNG = 0.0
0026          REDOIL = 0.0
0027          REDCOL = 0.0
0028          REDELT = 0.0
0029          SUM = 0.0
0030          FACT2 = 0.0
0031          SHPDEL = 0.0
0032          INV = 0
0033          NUM = 0
0034          IFLAG = 0
0035          BLGOOD(2) = 0
0036          DODSHP(2) = 0
        C
        C         INPUT QUANTITY OF EACH FUEL AVAILABLE LAST PERIOD
        C
0037          READ (5,540) ALP(2),ANG(2),AOIL(2),ACOAL(2),AELECT(2)
        C
        C         INPUT PAST PRODUCTION STATISTICS
        C
0038          READ (5,590) INVSHP(2),BLGSAL(2),ORDERS(1),ORDERS(2),
             2    DODCOM,AVEORD,DIST,PRODCY
        C
        C         INPUT THE PRODUCT MAN.,UNITS PRODUCED,EQUIP.AVAGE,
        C              SPECIAL FUEL NEEDS AND TYPE TRANSPO
        C
0039          READ (5,510) PROD1,PROD2,PROD3,PROD4,UNITS,EQAGE,SPNLP,SPNNG,
             2SPNOIL,SPNCL,SPNEL,LTRANS
0040          JTRANS = TRANPO(LTRANS)
        C
        C         INPUT QUANTITIES OF FUEL REQUIRED FOR NORMAL PRODUCTION
        C
0041          READ (5,540) QLP,QNG,QOIL,QCOAL,QELECT
        C
        C         CALCULATE THE AMOUNT OF EACH FUEL NEEDED TO PRODUCE ONE PRODUCT
        C
0042          ULP = QLP
0043          UNG = QNG
0044          UOIL = QOIL
0045          UCOAL = QCOAL
0046          UELECT = QELECT
0047          CALL FUELUN(ULP,UNG,UOIL,UCOAL,UELECT,UNITS)
        C
        C         INPUT CHANGE IN FUEL AVAILABLE
        C
0048          READ (5,545) CLP,CNG,COIL,CCOAL,CELECT
0049          CLP = CLP/100
0050          CNG = CNG/100
0051          COIL = COIL/100
0052          CCOAL = CCOAL/100
0053          CELECT = CELECT/100
0054          BRED = 0.0
0055          IF (CLP.GT.BRED)  BRED=CLP
0056          IF (CNG.GT.BRED)  BRED=CNG
0057          IF (COIL.GT.BRED)  BRED=COIL
0058          IF (CCOAL.GT.BRED)  BRED=CCOAL
0059          IF (CELECT.GT.BRED)  BRED=CELECT
```

```
C
      DO 1000 NPER=3,14
      N = NPER-2
      WRITE (6,660) N
      LPN = 1
      SMALL = 1.0
      SOUT = 0.0
      SCAP = 0.0
C
C         CALCULATE EFFECT OF FUEL REDUCTION
C
      REDLP = CLP - (.5*(CLP-REDLP))
      REDNG = CNG - (.5*(CNG-REDNG))
      REDOIL = COIL - (.5*(COIL-REDOIL))
      REDCOL = CCOAL - (.5*(CCOAL-REDCOL))
      REDELT = CELECT - (.5*(CELECT-REDELT))
      ALP(NPER) = QLP - (QLP*REDLP)
      ANG(NPER) = QNG - (QNG*REDNG)
      AOIL(NPER) = QOIL - (QOIL*REDOIL)
      ACOAL(NPER) = QCOAL - (QCOAL*REDCOL)
      AELECT(NPER) = QELECT - (QELECT*REDELT)
C
C         CALCULATE EFFECT OF CLIMATE CONTROL
C
   10 IF (NPER.NE.3)  GO TO 20
      READ (5,550) SPACE, IFUEL
   20 BTU = SPACE*2772.0
      JFUEL = ENERGY(IFUEL)
      NECFUL = BTU/FUEL(JFUEL)
      IF (JFUEL.EQ.1) ACOAL(NPER)=ACOAL(NPER)-NECFUL
      IF (JFUEL.EQ.2) ANG(NPER)=ANG(NPER)-NECFUL
      IF (JFUEL.EQ.3) AOIL(NPER)=AOIL(NPER)-NECFUL
      IF (JFUEL.EQ.4) AELECT(NPER)=AELECT(NPER)-NECFUL
      IF (JFUEL.EQ.5) ALP(NPER)=ALP(NPER)-NECFUL
C
C         CALCULATE THE EFFECT OF EQUIPMENT DETERIORATION
C
      DET = 1.0
      IF (EQAGE.GT.10.AND.EQAGE.LT.15)  DET=.90
      IF (EQAGE.GT.15.AND.EQAGE.LT.20)  DET=.85
      IF (EQAGE.GT.20) DET=.80
      ALP(NPER) = ALP(NPER)*DET
      ANG(NPER) = ANG(NPER)*DET
      AOIL(NPER) = AOIL(NPER)*DET
      ACOAL(NPER) = ACOAL(NPER)*DET
      AELECT(NPER) = AELECT(NPER)*DET
C
C         CALCULATE THE EFFECT OF SPECIAL FUEL NEEDS
C
      ALP(NPER) = ALP(NPER)-SPNLP
      ANG(NPER) = ANG(NPER)-SPNNG
      AOIL(NPER) = AOIL(NPER)-SPNOIL
      ACOAL(NPER) = ACOAL(NPER)-SPNCL
      AELECT(NPER) = AELECT(NPER)-SPNEL
C
C         ARE SUBSTITUTION RATIOS APPLICABLE
```

```
      C
            IF (NPER.NE.3)  GO TO 40
            READ (5,580) PCLOL,PELOL,PCLNG,PELNG,POLNG
            SRCLOL = SRCLOL*PCLOL
            SRELOL = SRELOL*PELOL
            SRCLNG = SRCLNG*PCLNG
            SRELNG = SRELNG*PELNG
            SROLNG = SROLNG*POLNG
      C
      C
      C        CALCULATE TOTAL AMOUNT OF EACH FUEL AVAILABLE FOR PRODUCTION USE
      C
         40 IF (ACOAL(NPER)-QCOAL) 60,60,50
         50 EXCOAL = ACOAL(NPER)-QCOAL
         60 IF (AELECT(NPER)-QELECT) 80,80,70
         70 EXELCT = AELECT(NPER)-QELECT
         80 IF (AOIL(NPER)-QOIL) 90,100,100
         90 IF (EXCOAL.GT.0.0.AND.SRCLOL.GT.0.0)  CLOIL=(EXCOAL/SRCLOL)
         92 AOIL(NPER) = AOIL(NPER)+CLOIL
            IF (AOIL(NPER)-QOIL) 100,109,95
         95 ANOIL = QOIL-AOIL(NPER)
            ANCOAL = ANOIL*SRCLOL
            EXCOAL = EXCOAL-ANCOAL
            AOIL(NPER) = QOIL
            GO TO 110
        100 IF (EXELCT.GT.0.0.AND.SRELOL.GT.0.0) ELOIL = (EXELCT/SRELOL)
        102 AOIL(NPER) = AOIL(NPER)+ELOIL
            IF (AOIL(NPER)-QOIL) 108,108,105
        105 ANOIL = QOIL-AOIL(NPER)
            ANELCT = ANOIL*SRELOL
            EXELCT = EXELCT-ANELCT
            AOIL(NPER) = QOIL
            GO TO 110
        108 IF (AELECT(NPER).GE.QELECT)  AELECT(NPER)=QELECT
            EXELCT = 0.0
        109 IF (ACOAL(NPER).GE.QCOAL)  ACOAL(NPER)=QCOAL
            EXCOAL = 0.0
        110 IF (ANG(NPER)-QNG) 120,150,150
        120 IF (EXCOAL.GT.0.0.AND.SRCLNG.GT.0.0)  CLNG=(EXCOAL/SRCLNG)
        122 ANG(NPER) = ANG(NPER)+CLNG
            IF (ANG(NPER)-QNG) 130,150,125
        125 ANNG = QNG-ANG(NPER)
            ANCOAL = ANNG*SRCLNG
            EXCOAL = EXCOAL-ANCOAL
            ANG(NPER) = QNG
            GO TO 150
        130 IF (EXELCT.GT.0.0.AND.SRELNG.GT.0.0)  ELNG = (EXELCT/SRELNG)
        132 ANG(NPER) = ANG(NPER)+ELNG
            IF (ANG(NPER)-QNG) 140,150,135
        135 ANNG = QNG-ANG(NPER)
            ANELCT = ANNG*SRELNG
            EXELCT = EXELCT-ANELCT
            ANG(NPER) = QNG
            GO TO 150
        140 IF (EXOIL.GT.0.0.AND.SROLNG.GT.0.0)  OLNG = (EXOIL/SROLNG)
        142 ANG(NPER) = ANG(NPER)+OLNG
```

```
0152              IF (ANG(NPER)-QNG) 150,150,145
0153          145 ANNG = QNG-ANG(NPER)
0154              ANOL = ANNG*SROLNG
0155              EXOIL = EXOIL-ANOL
0156              ANG(NPER) = QNG
0157              GO TO 150
0158          147 IF (AOIL(NPER).GE.QOIL)  AOIL(NPER)=QOIL
0159              EXOIL = 0.0
0160          148 IF (AELECT(NPER).GE.QELECT)  AELECT(NPER)=QELECT
0161              EXELCT = 0.0
0162          149 IF (ACOAL(NPER).GE.QCOAL)  ACOAL(NPER)=QCOAL
0163              EXCOAL = 0.0
            C
            C        CALCULATE PRODUCTION CAPACITY FOR FUEL AVAILABLE
            C        DETERMINE LIMITING FUEL AND END PRODUCTION CAPACITY
            C
0164          150 FIN = UNITS
0165              CALL PRODCP(ALP(NPER),ACOAL(NPER),AELECT(NPER),AOIL(NPER),
                 2   ANG(NPER),ULP,UCOAL,UELECT,UOIL,UNG,FIN)
0166              ENPROD = UNITS
0167              IF (FIN.LT.UNITS) ENPROD=FIN
0168              EFFACT = PRODEF(NPER)
0169              ENPROD = ENPROD - (ENPROD*EFFACT)
0170              DUNIT = ENPROD-UNITS
0171              IF (NPER.NE.3)  GO TO 300
            C
            C        INPUT AMOUNT OF DIESEL FUEL AVAIL.
            C
0172          200 READ (5,520) DIESEL
            C
            C        INPUT NUMBER OF RAW MATERIAL TYPES
            C
0173              READ (5,560) NUMMAT
0174              DO 290 I=1,NUMMAT
0175              READ (5,500) RMINV(I),RMU(I)
0176          290 CONTINUE
            C
            C        INPUT NUMBER OF SUPPLIERS
            C
0177          300 READ (5,560) NUMSUP
0178              WRITE (6,670) LPN
0179              WRITE (6,600)
0180              DO 350 N=1,NUMSUP
            C
            C        INPUT THE AMOUNT OF EACH FUEL AVAILABLE
            C
0181              READ (5,540) SLP,SNG,SOIL,SCOAL,SELECT
            C
            C        INPUT SUPPLIER'S NAME,AVE.QUANTITY ORDERED,PRODUCTS WEIGHT,
            C              DISTANCE TRANSPORTED,METHOD OF TRANSPORTATION,
            C              PRODUCT CODE, AND % CAP. ORDERED
            C
0182              READ (5,570) SUP1,SUP2,SUP3,SUP4,CAP,PRODWT,AVDIST,LTRANS,MPN,PCO
0183              KTRANS = TRANPO(LTRANS)
            C
            C        INPUT FUEL REQUIRMENTS FOR NORMAL PRODUCTION
```

energy, to which it reacts immediately.

```
FORTRAN IV G LEVEL  21                MAIN              DATE = 77050          15/36/59
                C
0184                  READ (5,540) RLP,RNG,ROIL,RCCAL,RELECT
0185                  RLP = RLP/FUEL(5)
0186                  RNG = RNG/FUEL(2)
0187                  ROIL = ROIL/FUEL(3)
0188                  RCOAL = RCOAL/FUEL(1)
0189                  RELECT = RELECT/FUEL(4)
                C
                C
                C        CALCULATE THE AMOUNT OF EACH FUEL NEEDED TO PRODUCE ONE PRODUCT
                C
0190              310 CALL FUELUN(RLP,RNG,ROIL,RCOAL,RELECT,CAP)
                C
                C        CALCULATE PRODUCTION CAPACITY FOR FUEL AVAILABLE
                C        DETERMINE LIMITING FUEL AND END PRODUCTION CAPACITY
                C
0191              330 FIN = CAP
0192                  CALL PRODCP(SLP,SCOAL,SELECT,SOIL,SNG,RLP,RCOAL,RELECT,ROIL,RNG,
                     2FIN)
0193                  ENCAP = CAP
0194                  IF (FIN.LT.CAP) ENCAP=FIN
                C
                C        CALCULATE EFFECT OF TRANSPORTATION SHORTAGE
                C
0195                  AFUEL = TRANS(KTRANS)*(CAP/(2000/PRODWT))*AVDIST
0196                  SHORT = 1.0
0197                  IF (DIESEL.LT.AFUEL) SHORT=DIESEL/AFUEL
0198                  ENTRAN = SHORT*CAP
0199                  OUTPUT = ENCAP
0200                  IF (ENTRAN.LT.ENCAP) OUTPUT=ENTRAN
0201                  IF (NPER.NE.3)  GO TO 336
0202                  CALL RDMNUM(IY,IY,RN1)
0203                  IRN1 = RN1*100.0
0204                  MRAND(N) = MOD(IRN1,4)
0205              336 MRAND(N) = MRAND(N)+1
0206                  EFFACT = SUPEF(MRAND(N))
0207                  OUTPUT = OUTPUT - (OUTPUT*EFFACT)
0208                  SCAPER = (OUTPUT/CAP)*100
                C
                C        CHECK PRODUCT CODE
                C
0209                  IF (MPN.NE.LPN)  GO TO 340
0210                  WRITE (6,610) SUP1,SUP2,SUP3,SUP4,OUTPUT,SCAPER
0211                  CALL CHART(PCO,SHPDEL)
0212                  SUM = SUM+SHPDEL
0213                  NUM = NUM+1
0214                  SOUT = SOUT+OUTPUT
0215                  SCAP = SCAP+CAP
0216                  GO TO 350
0217              340 CAPPER = SOUT/SCAP
0218                  IF (NPER.EQ.3)  FINOUT=UNITS
                C
                C        CALCULATE RAW MATERIALS NEEDED FOR THIS PERIOD
                C
0219                  IF (RMINV(LPN).LE.1)     RMINV(LPN)=1
0220                  IF (NPER.EQ.3)  UPUROR(LPN)=1.0
```

```
0221          REDPUR = CANBLG(NPER)
0222          UPUROR(LPN) = UPUROR(LPN) - (UPURUR(LPN)*REDPUR)
0223          PURORD(LPN) = FINOUT*RMU(LPN) - UPUROR(LPN) +
             2   ((SCAP/2)/RMINV(LPN))
0224          SUPLYS = PURORD(LPN)
0225          IF (SOUT.LT.PURORD(LPN))  SUPLYS = SOUT
0226          IF (PURORD(LPN).GT.SOUT)  UPUROR(LPN)=SOUT-PURORD(LPN)
0227          IF (UPUROR(LPN).EQ.0.0)  UPUROR(LPN)=1.0
0228          IF (NUM.NE.0)  GO TO 342
0229          CALL CHART(PCO,SHPDEL)
0230          SUM = SHPDEL
0231          NUM = 1
0232      342 PERDEL = SUM/NUM
0233          SUM = 0.0
0234          NUM = 0
        C
        C        CALCULATE ACTUAL RAW MATERIAL INVENTORY FOR NEXT PERIOD
        C
0235          SUPSHP(LPN) = SUPLYS - (PERDEL*SUPLYS)
0236          RMINV(LPN) = RMINV(LPN) + SUPSHP(LPN)
0237          RMUSE(LPN) = RMU(LPN)*ENPROD
0238          IF (RMINV(LPN).LE.1)    RMINV(LPN)=1
0239          STOCK = RMINV(LPN)
0240          USE = RMUSE(LPN)
0241          CAPPER = STOCK/USE
0242      346 SOUT = OUTPUT
0243          SCAP = CAP
0244          IF (CAPPER.LT.SMALL) SMALL=CAPPER
0245          WRITE (6,680)
0246          IP = PURORD(LPN)
0247          IS = SUPSHP(LPN)
0248          WRITE (6,690) IP,IS,RMINV(LPN)
0249          WRITE (6,620)
0250          IF (IFLAG.GT.1)  GO TO 355
0251          LPN = MPN
0252          WRITE (6,670) LPN
0253          WRITE (6,600)
0254          WRITE (6,610) SUP1,SUP2,SUP3,SUP4,OUTPUT,SCAPER
0255      350 CONTINUE
0256          IFLAG = 5
0257          GO TO 340
0258      355 IFLAG = 0
0259          DO 360 N=1,NUMSUP
0260          RMINV(N) = RMINV(N) - (RMUSE(N)*SMALL)
0261      360 CONTINUE
        C
        C        CALCULATE FINAL PRODUCTION OUTPUT
        C
0262          FINOUT = SMALL*ENPROD
0263          IF (ORDERS(NPER-2).LT.FINOUT)  FINOUT=ORDERS(NPER-2)
0264          FINOUT = FINOUT + (PRODCY*DUNIT)
0265          WRITE (6,620)
0266          WRITE (6,620)
0267          WRITE (6,630)
0268          WRITE (6,640) PROD1,PROD2,PROD3,PROD4,FINOUT
        C
```

```
                C
                C          COMPUTE THE FOLLOWING FOR THIS PERIOD :
                C          NUMBER OF ORDERS RECEIVED
                C          NUMBER OF DOD UNITS SHIPPED
                C          BACKLOG OF DOD ORDERS
                C          BACKLOG OF SALES ORDERS
                C          AMOUNT OF INVENTORY SHIPPED
                C          REMAINING FINISHED PRODUCT INVENTORY
                C
0269                  OFACT = ORFACT(NPER)
0270                  ORDERS(NPER) = (1.0-BRED) * ORDERS(2) * OFACT
0271                  DODSHP(NPER) = DODCOM * FACT2
0272                  IF (DODSHP(NPER).LT.(INV+FINOUT))  GO TO 375
0273                  DODSHP(NPER) = INV + FINOUT
0274                  INV = INV - DODSHP(NPER)
0275              375 IF (NPER.GE.5) FACT2=1.0
0276                  INV = INV - DODSHP(NPER)
0277                  BLGDOD(NPER) = BLGDOD(NPER-1) + (DODCOM-DODSHP(NPER))
0278                  REDBLG = CANBLG(NPER)
0279                  INVSHP(NPER) = ORDERS(NPER-1) - (DIST/10)*EFFACT
0280                  IF ((INV+FINOUT).LT.ORDERS(NPER-1))
                    2    INVSHP(NPER)=(INV+FINOUT)-(DIST/10)*EFFACT
0281                  IF (INVSHP(NPER).LT.0)  INVSHP(NPER)=0
0282                  BLGSAL(NPER-1) = BLGSAL(NPER-1) - (REDBLG*BLGSAL(NPER-1))
0283                  BLGSAL(NPER) = BLGSAL(NPER-1) + ORDERS(NPER-1)-INVSHP(NPER)
0284                  IF (NPER.LT.5)  GO TO 400
0285              400 IF (BLGSAL(NPER).LT.0) BLGSAL(NPER) = 0
0286                  INV = INV + FINOUT - INVSHP(NPER)
0287                  IF (INV.LE.0) INV=0
0288                  WRITE (6,700)
0289                  WRITE (6,705) ORDERS(NPER),DODSHP(NPER),BLGDOD(NPER)
0290                  WRITE (6,710)
0291                  WRITE (6,715) INVSHP(NPER),BLGSAL(NPER),INV
0292             1000 CONTINUE
0293             2000 CONTINUE
                C
                C
0294              500 FORMAT (I10,F8.4)
0295              510 FORMAT (4A4,I10,I2,5F9.1,A4)
0296              520 FORMAT (F15.1)
0297              530 FORMAT (5F10.5)
0298              540 FORMAT (5F15.1)
0299              545 FORMAT (5F7.4)
0300              550 FORMAT (F15.1,A4)
0301              560 FORMAT (I4)
0302              570 FORMAT (4A4,I10,F10.2,F10.2,A4,I2,F4.2)
0303              580 FORMAT (5I1)
0304              590 FORMAT (7I10,F5.3)
0305              600 FORMAT ('0', 10X,'SUPPLIER''S NAME          OUTPUT CAPIBILITY
                    2      PERCENT OF NORMAL CAP.')
0306              610 FORMAT ('0',7X,4A4,12X,F15.2,20X,F7.3)
0307              620 FORMAT ('0')
0308              630 FORMAT ('0',10X,'DOD  PRODUCT           OUTPUT CAPIBILITY')
0309              640 FORMAT ('0',7X,4A4,12X,I10,//)
0310              660 FORMAT ('1',10X,'STATISTICS FOR PERIOD #',I2,///)
```

```
0311            670 FORMAT ('0',5X,'RAW MATERIAL #',I3)
0312            680 FORMAT ('C',10X,'PURCHASES  ORDERED',5X,'SUPPLYS RECEIVED',5X,'BEG
                   2INNING RAW MATERIAL  INVENTORY')
0313            690 FORMAT ('0',14X,I10,12X,I10,18X,I10,//)
0314            700 FORMAT ('0',10X,'ORDERS  RECEIVED',5X,'IPP SHIPMENT',5X,'BACKLOG
                   2IPP')
0315            705 FORMAT ('0',13X,I10,6X,I10,6X,I10)
0316            710 FORMAT ('0',10X,'INVENTORY SHIPPED',5X,'BACKLOG ORDERS',5X,'FINISH
                   2ED PRODUCT INVENTORY')
0317            715 FORMAT ('0',14X,I10,7X,I10,13X,I10)
0318                STOP
0319                END
```

```
      FUNCTION TRANPO(LTRANS)
      INTEGER AIRE,RAIL,TRUK,WATR
      DATA AIRE/'AIRE'/,RAIL/'RAIL'/,TRUK/'TRUK'/,WATR/'WATR'/
      TRANPO=0.0
      IF (LTRANS.EQ.AIRE) TRANPO=1.0
      IF (TRANPO.GT.0.5)  GO TO 100
   10 IF (LTRANS.EQ.RAIL) TRANPO=2.0
      IF (TRANPO.GT.0.5)  GO TO 100
   20 IF (LTRANS.EQ.WATR) TRANPO=3.0
      IF (TRANPO.GT.0.5)  GO TO 100
   30 IF (LTRANS.EQ.TRUK) TRANPO=4.0
  100 RETURN
      END
```

```
0001              FUNCTION ENERGY(IFUEL)
0002              INTEGER NGAS,COAL,FOIL,ELET,LGAS
0003              DATA NGAS/'NGAS'/,COAL/'COAL'/,FOIL/'FOIL'/,ELET/'ELET'/,
                 2    LGAS/'LGAS'/
0004              ENERGY = 0.0
0005              IF (IFUEL.EQ.COAL) ENERGY=1.0
0006              IF (ENERGY.GT.0.5)  GO TO 100
0007           10 IF (IFUEL.EQ.NGAS) ENERGY=2.0
0008              IF (ENERGY.GT.0.5)  GO TO 100
0009           20 IF (IFUEL.EQ.FOIL) ENERGY=3.0
0010              IF (ENERGY.GT.0.5)  GO TO 100
0011           30 IF (IFUEL.EQ.ELET) ENERGY=4.0
0012              IF (ENERGY.GT.0.5)  GO TO 100
0013           40 IF (IFUEL.EQ.LGAS) ENERGY=5.0
0014          100 RETURN
0015              END
```

```
FORTRAN IV G LEVEL  21                    RDMNUM               DATE = 77050            15/36/59

              SUBROUTINE RDMNUM(IX,IY,YFL)
              IY = IX*65539
              IF (IY) 5,10,10
            5 IY = IY+2147483647+1
           10 YFL = IY
              YFL = YFL*0.4656613E-9
              RETURN
              END
```

```
      SUBROUTINE FUELUN(ULP,UNG,UOIL,UCOAL,UELECT,MUNITS)
      ULP = ULP/MUNITS
      UNG = UNG/MUNITS
      UOIL = UOIL/MUNITS
      UCOAL = UCOAL/MUNITS
      UELECT = UELECT/MUNITS
      IF (ULP.EQ.0.0)  ULP=.0001
      IF (UNG.EQ.0.0)  UNG=.0001
      IF (UOIL.EQ.0.0)  UOIL=.0001
      IF (UCOAL.EQ.0.0)  UCOAL=.0001
      IF (UELECT.EQ.0.0)  UELECT=.0001
      RETURN
      END
```

```
0001            SUBROUTINE PRODCP(BLP,BCOAL,BELECT,BOIL,BNG,ULP,UCOAL,UELECT,UOIL,
               2UNG,FIN)
0002            CAPLP = BLP/ULP
0003            CAPNG = BNG/UNG
0004            CAPOL = BOIL/UOIL
0005            CAPCL = BCOAL/UCOAL
0006            CAPEL = BELECT/UELECT
0007            IF (CAPLP.LT.1.0) CAPLP=1000000000
0008            IF (CAPNG.LT.1.0) CAPNG=1000000000
0009            IF (CAPOL.LT.1.0) CAPOL=1000000000
0010            IF (CAPCL.LT.1.0) CAPCL=1000000000
0011            IF (CAPEL.LT.1.0) CAPEL=1000000000
0012            SM4 = CAPNG
0013            IF (CAPLP.LT.SM4) SM4=CAPLP
0014            IF (CAPOL.LT.SM4) SM4=CAPOL
0015            IF (CAPCL.LT.SM4) SM4=CAPCL
0016            IF (CAPEL.LT.SM4) SM4=CAPEL
0017            FIN = SM4
0018            RETURN
0019            END
```

```
      SUBROUTINE CHART(PER,TABLE)
      TABLE = 0.0
      IF (PER.GT.0.95)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   95 IF (PER.GT.0.90)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   90 IF (PER.GT.0.85)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   85 IF (PER.GT.0.80)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   80 IF (PER.GT.0.75)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   75 IF (PER.GT.0.70)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   70 IF (PER.GT.0.65)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   65 IF (PER.GT.0.60)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   60 IF (PER.GT.0.55)  TABLE=1.00
      IF (TABLE.GT.0.0)  GO TO 100
   55 IF (PER.GT.0.50)  TABLE=0.99
      IF (TABLE.GT.0.0)  GO TO 100
   50 IF (PER.GT.0.45)  TABLE=0.99
      IF (TABLE.GT.0.0)  GO TO 100
   45 IF (PER.GT.0.40)  TABLE=0.98
      IF (TABLE.GT.0.0)  GO TO 100
   40 IF (PER.GT.0.35)  TABLE=0.98
      IF (TABLE.GT.0.0)  GO TO 100
   35 IF (PER.GT.0.30)  TABLE=0.97
      IF (TABLE.GT.0.0)  GO TO 100
   30 IF (PER.GT.0.25)  TABLE=0.97
      IF (TABLE.GT.0.0)  GO TO 100
   25 IF (PER.GT.0.20)  TABLE=0.96
      IF (TABLE.GT.0.0)  GO TO 100
   20 IF (PER.GT.0.15)  TABLE=0.96
      IF (TABLE.GT.0.0)  GO TO 100
   15 IF (PER.GT.0.10)  TABLE=0.96
      IF (TABLE.GT.0.0)  GO TO 100
   10 IF (PER.GT.0.05)  TABLE=0.95
      IF (TABLE.GT.0.0)  GO TO 100
    5 IF (PER.GT.0.00)  TABLE=0.95
  100 TABLE = 1.00 - TABLE
      RETURN
      END
```

FORTRAN IV G LEVEL 21 PRODEF DATE = 77050 15/36/59

```
      FUNCTION PRODEF(NPERD)
      PRODEF = 0.0
   30 IF (NPERD.EQ.3)   PRODEF=1.00
      IF (PRODEF.GT.0.0)  GO TO 200
   40 IF (NPERD.EQ.4)   PRODEF=1.00
      IF (PRODEF.GT.0.0)  GO TO 200
   50 IF (NPERD.EQ.5)   PRODEF=0.85
      IF (PRODEF.GT.0.0)  GO TO 200
   60 IF (NPERD.EQ.6)   PRODEF=0.80
      IF (PRODEF.GT.0.0)  GO TO 200
   70 IF (NPERD.EQ.7)   PRODEF=0.90
      IF (PRODEF.GT.0.0)  GO TO 200
   80 IF (NPERD.EQ.8)   PRODEF=1.00
      IF (PRODEF.GT.0.0)  GO TO 200
   90 IF (NPERD.EQ.9)   PRODEF=1.05
      IF (PRODEF.GT.0.0)  GO TO 200
  100 IF (NPERD.EQ.10)   PRODEF=1.10
      IF (PRODEF.GT.0.0)  GO TO 200
  110 IF (NPERD.EQ.11)   PRODEF=1.15
      IF (PRODEF.GT.0.0)  GO TO 200
  120 IF (NPERD.EQ.12)   PRODEF=1.10
      IF (PRODEF.GT.0.0)  GO TO 200
  130 IF (NPERD.EQ.13)   PRODEF=1.05
      IF (PRODEF.GT.0.0)  GO TO 200
  140 IF (NPERD.EQ.14)   PRODEF=1.06
  200 PRODEF = 1.00 - PRODEF
      RETURN
      END
```

```
      FUNCTION SUPEF(NPERD)
      SUPEF = 0.0
05    IF (NPERD.EQ.0)  SUPEF=0.94
      IF (SUPEF.GT.0.0)  GO TO 200
10    IF (NPERD.EQ.1)  SUPEF=0.84
      IF (SUPEF.GT.0.0)  GO TO 200
20    IF (NPERD.EQ.2)  SUPEF=0.89
      IF (SUPEF.GT.0.0)  GO TO 200
30    IF (NPERD.EQ.3)  SUPEF=1.00
      IF (SUPEF.GT.0.0)  GO TO 200
40    IF (NPERD.EQ.4)  SUPEF=0.91
      IF (SUPEF.GT.0.0)  GO TO 200
50    IF (NPERD.EQ.5)  SUPEF=0.86
      IF (SUPEF.GT.0.0)  GO TO 200
60    IF (NPERD.EQ.6)  SUPEF=0.96
      IF (SUPEF.GT.0.0)  GO TO 200
70    IF (NPERD.EQ.7)  SUPEF=1.01
      IF (SUPEF.GT.0.0)  GO TO 200
80    IF (NPERD.EQ.8)  SUPEF=1.06
      IF (SUPEF.GT.0.0)  GO TO 200
90    IF (NPERD.EQ.9)  SUPEF=1.11
      IF (SUPEF.GT.0.0)  GO TO 200
100   IF (NPERD.EQ.10)  SUPEF=1.15
      IF (SUPEF.GT.0.0)  GO TO 200
110   IF (NPERD.EQ.11)  SUPEF=1.09
      IF (SUPEF.GT.0.0)  GO TO 200
120   IF (NPERD.EQ.12)  SUPEF=1.05
      IF (SUPEF.GT.0.0)  GO TO 200
130   IF (NPERD.EQ.13)  SUPEF=1.04
      IF (SUPEF.GT.0.0)  GO TO 200
140   IF (NPERD.EQ.14)  SUPEF=0.99
      IF (SUPEF.GT.0.0)  GO TO 200
150   IF (NPERD.EQ.15)  SUPEF=0.98
      IF (SUPEF.GT.0.0)  GO TO 200
160   IF (NPERD.EQ.16)  SUPEF=1.01
200   SUPEF = 1.00 - SUPEF
      RETURN
      END
```

```
      FUNCTION CANBLG(NPERD)
      CANBLG = 0.0
   30 IF (NPERD.EQ.3)  CANBLG=1.00
      IF (CANBLG.GT.0.0)  GO TO 200
   40 IF (NPERD.EQ.4)  CANBLG=1.00
      IF (CANBLG.GT.0.0)  GO TO 200
   50 IF (NPERD.EQ.5)  CANBLG=0.90
      IF (CANBLG.GT.0.0)  GO TO 200
   60 IF (NPERD.EQ.6)  CANBLG=0.80
      IF (CANBLG.GT.0.0)  GO TO 200
   70 IF (NPERD.EQ.7)  CANBLG=0.70
      IF (CANBLG.GT.0.0)  GO TO 200
   80 IF (NPERD.EQ.8)  CANBLG=0.60
      IF (CANBLG.GT.0.0)  GO TO 200
   90 IF (NPERD.EQ.9)  CANBLG=0.50
      IF (CANBLG.GT.0.0)  GO TO 200
  100 IF (NPERD.EQ.10)  CANBLG=0.40
      IF (CANBLG.GT.0.0)  GO TO 200
  110 IF (NPERD.EQ.11)  CANBLG=0.30
      IF (CANBLG.GT.0.0)  GO TO 200
  120 IF (NPERD.EQ.12)  CANBLG=0.20
      IF (CANBLG.GT.0.0)  GO TO 200
  130 IF (NPERD.EQ.13)  CANBLG=0.10
      IF (CANBLG.GT.0.0)  GO TO 200
  140 IF (NPERD.EQ.14)  CANBLG=0.05
  200 CANBLG = 1.00 - CANBLG
      RETURN
      END
```

FORTRAN IV G LEVEL 21 ORFACT DATE = 77050 15/36/59

```
      FUNCTION ORFACT(NPERD)
      ORFACT = 0.0
   30 IF (NPERD.EQ.3)  ORFACT=1.30
      IF (ORFACT.GT.0.0)  GO TO 200
   40 IF (NPERD.EQ.4)  ORFACT=1.70
      IF (ORFACT.GT.0.0)  GO TO 200
   50 IF (NPERD.EQ.5)  ORFACT=1.80
      IF (ORFACT.GT.0.0)  GO TO 200
   60 IF (NPERD.EQ.6)  ORFACT=1.65
      IF (ORFACT.GT.0.0)  GO TO 200
   70 IF (NPERD.EQ.7)  ORFACT=1.55
      IF (ORFACT.GT.0.0)  GO TO 200
   80 IF (NPERD.EQ.8)  ORFACT=1.25
      IF (ORFACT.GT.0.0)  GO TO 200
   90 IF (NPERD.EQ.9)  ORFACT=1.10
      IF (ORFACT.GT.0.0)  GO TO 200
  100 IF (NPERD.EQ.10)  ORFACT=1.00
      IF (ORFACT.GT.0.0)  GO TO 200
  110 IF (NPERD.EQ.11)  ORFACT=0.90
      IF (ORFACT.GT.0.0)  GO TO 200
  120 IF (NPERD.EQ.12)  ORFACT=0.90
      IF (ORFACT.GT.0.0)  GO TO 200
  130 IF (NPERD.EQ.13)  ORFACT=1.00
      IF (ORFACT.GT.0.0)  GO TO 200
  140 IF (NPERD.EQ.14)  ORFACT=1.05
  200 RETURN
      END
```

AD-A044 131 MISSOURI UNIV-ROLLA DEPT OF ENGINEERING MANAGEMENT F/G 10/3
ENERGY SYSTEM ANALYSIS PROCEDURE (ESAP).(U)
JUN 77 J M AMOS F33615-76-C-5384

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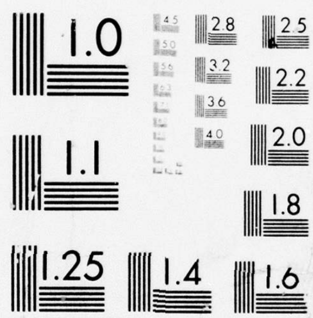

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX B

LISTING OF VARIABLE DEFINITIONS

APPENDIX B

LISTING OF VARIABLE DEFINITIONS

ARRAY VARIABLES

ACOAL	quantity of coal available each period
AELECT	quantity of electricity available each period
ALP	quantity of LP gas available each period
ANG	quantity of natural gas available each period
AOIL	quantity of oil available each period
BLGDOD	number of unfilled DOD requests each period
BLGSAL	number of unfilled orders each period
DODSHP	number of products shipped for DOD use each period
INVSHP	number of products shipped each period
ORDERS	number of orders received each period
PURORD	supplies ordered each period
RMINV	raw material inventory, current
RMU	amount of raw material required to manufacture one unit
RMUSE	amount of raw material used each period
SUPSHP	supplies received each period
UPUROR	supplies ordered and not received

CONSTANTS

FUEL	BTU per unit of fuel
IY	initial value for random number generator
SRCLNG	fuel substitution ratios, coal to natural gas
SRCLOL	fuel substitution ratios, coal to oil
SRELNG	fuel substitution ratios, electricity to natural gas

SRELOL	fuel substitution ratios, electricity to oil
SROLNG	fuel substitution ratios, oil to natural gas
TRANS	fuel required per ton mile

I/O VARIABLES

AVDIST	distance from supplier
AVEORD	average number of products ordered from manufacturer per period
BLGSAL	backlog on orders received
CAP	number of units you normally order from supplier
CCOAL	change in coal available
CELECT	change in electricity available
CLP	change in LP gas available
CNG	change in natural gas available
COIL	change in oil available
DIESEL	quantity of diesel fuel available for transportation
DIST	average distance manufacturer's products are shipped
DODCOM	number of products committed to DOD production
EQAGE	average age of production equipment
IFUEL	fuel used to heat plant
INONE	number of companies to be processed
INVSHP	finished products shipped
LTRANS	method of transportation
MPN	product code number
NUMMAT	number of raw materials required
NUMSUP	number of suppliers for raw material
ORDERS	number of products ordered from manufacturer this period
PCO	percent of suppliers output ordered by manufacturer

PCLNG	capability to substitute coal for natural gas
PCLOL	capability to substitute coal for oil
PELNG	capability to substitute electricity for natural gas
PELOL	capability to substitute electricity for oil
POLNG	capability to substitute oil for natural gas
PRODCY	production cycle time
PRODWT	weight of one unit
PROD1 - PROD4	name of your product
QCOAL	quantity of coal
QELECT	quantity of electricity
QLP	quantity of LP gas
QNG	quantity of natural gas
QOIL	quantity of oil
RCOAL	quantity of coal required to produce "CAP" units
RELECT	quantity of electricity required to produce "CAP" units
RLP	quantity of LP gas required to produce "CAP" units
RNG	quantity of natural gas required to produce "CAP" units
ROIL	quantity of oil required to produce "CAP" units
RMINV	raw material inventory at the beginning of the period
RMU	amount of raw material required per product
SCOAL	quantity of coal available to supplier for production
SELECT	quantity of electricity available to supplier for production
SLP	quantity of LP gas available to supplier for production
SNG	quantity of natural gas available to supplier for production
SOIL	quantity of oil available to supplier for production

SPACE	area of plant
SPNCL	special (non-production) coal requirements
SPNEL	special (non-production) electricity requirements
SPNLP	special (non-production) LP gas requirements
SPNNG	special (non-production) natural gas requirements
SPNOIL	special (non-production) oil requirements
SUP1 - SUP4	name of supplier
UNITS	number of units normally produced

VARIABLES

AFUEL	fuel required to transport goods
ANCOAL	quantity of extra coal used as a substitute fuel
ANELCT	quantity of extra electricity used as a substitute fuel
ANNG	quantity of natural gas needed for normal production
ANOIL	quantity of oil needed for normal production
ANOL	quantity of extra oil used as a substitute fuel
BTU	BTU of energy required to heat plant (SPACE)
CAPPER	percent of supplies ordered which were manufactured
CLNG	BTU equivalent of natural gas available from extra electricity
CLOIL	BTU equivalent of oil available from extra coal
DET	equipment deterioration factor (EQAGE)
DUNIT	delta unit...actual output - capacity
EFACT	efficiency delay factor
ELNG	BTU equivalent of natural gas available from extra electricity
ELIOL	BTU equivalent of oil available from extra electricity

ENCAP	supplier capacity based on available fuel quantities
ENPROD	production output based on plant capacity (UNITS)
ENTRAN	number of products transported
EXCOAL	extra coal...available - required
EXELCT	extra electricity...available - required
EXNG	extra natural gas...available - required
EXOIL	extra oil...available - required
FACT2	response delay to DOD commitment
FIN	production output based on available fuel quantities
FINOUT	final output capability
I	loop control variable for number of supplies
IFLAG	transfer control variable...based on product codes
INV	quantity of finished goods in inventory
IP	output variable - quantity of raw material ordered
IS	output variable - quantity of raw material shipped
JFUEL	array position of fuel type (IFUEL)
JTRANS	array position of production transportation type (LTRANS)
KTRANS	array position of supplier transportation type (LTRANS)
LPN	contains product code number last processed
N	period number with respect to calendar (NPER-2)
NECFUL	quantity of fuel required for heating
NPER	period number with respect to program
NUM	number of suppliers per supply
NUMCOM	loop control variable for number of companies
OLNG	BTU equivalent of natural gas available from extra oil

OUTPUT	output based on efficiency delay
PERDEL	delay factor for supplies received
REDBLG	reduction factor for products on backlog
REDCOL	actual reduction of coal on change input (CCOAL)
REDELT	actual reduction of electricity on change input (CELECT)
REDLP	actual reduction of LP gas on change input (CLP)
REDNG	actual reduction of natural gas on change input (CNG)
REDOIL	actual reduction of oil on change input (COIL)
REDPUR	reduction factor for supplies on backlog
SCAP	suppliers capacity...summation per supply
SCAPER	percent of supplies ordered which were shipped
SHORT	percent of necessary fuel not available
SHPDEL	delay in receiving goods from suppliers
SMALL	limiting supply in production process
SOUT	suppliers output...summation per supply
STOCK	current raw material inventory
SUM	summation of shipping delays (SHPDEL) per supply
SUPLYS	amount of raw material necessary for normal production
UCOAL	quantity of coal required to produce one unit
UELECT	quantity of electricity required to produce one unit
ULP	quantity of LP gas required to produce one unit
UNG	quantity of natural gas required to produce one unit
UOIL	quantity of oil required to produce one unit
USE	amount of raw material used this period

APPENDIX C

QUESTIONNAIRE

University of Missouri-Rolla
School of Engineering
Department of Engineering Management

QUESTIONNAIRE

For

IMPACT OF ENERGY SHORTAGES ON

INDUSTRIAL PREPAREDNESS PLANNING PROGRAMS

Contract #F33615-76-C-5384

Project Director: John M. Amos

Questionnaire on "Impact of Energy Shortages on Industrial Preparedness Planning Programs"

Units: Coal/Ton
Natural Gas/Cubic Feet
Oil/Gallon
Electricity/KWH
LP Gas/Gallon

Name of Company ______________________________

Name of Product ______________________________

Number of Units Normally Produced Per Year ______________________________

Number of Units Ordered From You 2 Months Ago __________ Last Month __________

Average Number of Units Ordered From You Per Month ______________________________

Number of Products Shipped Last Month __________ Backlog of Shipments Last Month _____

Average Distance Products are Shipped ______________________________

Number of Products Committed to DOD (Form 1519) __________ Production Cycle (Mo.) ____

Average Age of Production Equipment (Years) ________

Does the plant have any special fuel requirements that have priority over general operations? Indicate amounts:

Coal __________ Electricity __________

Natural Gas __________ LP Gas __________

Oil __________

Most Common Method of Transportation Used (Air, Rail, Truck, Barge) ______________

Total Amount of Fuel Consumed Per Year:

Coal __________ Electricity __________

Natural Gas __________ LP Gas __________

Oil __________

Indicate Type and Amount of Fuel Consumed Per Year for Heating ______________

Indicate Type and Amount of Fuel Consumed Per Year for Cooling ______________

Can you make the following Fuel Substitutions immediately?

Coal for Oil	(Yes)____	(No) ____
Electricity for Oil	(Yes)____	(No) ____
Coal for Natural Gas	(Yes)____	(No) ____
Electricity for Natural Gas	(Yes)____	(No) ____
Oil for Natural Gas	(Yes)____	(No) ____

Raw Materials you use

Type of Raw Material:					
Number Used/Year					
Av. Raw Material Inventory Beginning of Month					
Quantity Raw Material Used to Produce One Product					

Kind of Raw Material	Supplier's Name	Supplier's Location	No. Units Ordered/Year	Method of Transportation Used by Supplier	Percentage of Supplier's Output You Order

APPENDIX D

LISTING OF SAMPLE OUTPUT

STATISTICS FOR PERIOD # 1

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	583800.12	70.000

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
840009	55461C	594610

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1059100.00	62.300
RUBBER	1647058.00	48.443

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
5040011	2570850	2770850

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	705600.12	58.800

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
1176009	705600	765600

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	230904	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
728000	0	1000000
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
230888	529112	16

STATISTICS FOR PERIOD # 2

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	531258.12	63.700
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
718020	504695	637496

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1190000.00	70.000
RUBBER	1745097.00	51.326
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
7654701	2788342	2788343

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	747600.12	62.300
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
1116945	747600	866668

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	232361	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
951999	0	2000000
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
232366	1024746	11

STATISTICS FOR PERIOD # 3

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	502068.12	60.200
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
632810	476964	649736

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1082900.00	63.700
RUBBER	1960784.00	57.670
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
9585975	2891499	2891500

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	840000.12	70.000
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
983023	840000	1056054

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	236548	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
1008000	0	3000000
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
236559	1637711	0

STATISTICS FOR PERIOD # 4

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	560448.06	67.200
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
577692	532425	700244

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1023400.06	60.200
RUBBER	1784313.00	52.480
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
10622409	2667327	2667328

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	764400.19	63.700
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
776755	764400	1145770

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	216397	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
923999	216397	3783603
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	2318168	0

STATISTICS FOR PERIOD # 5

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	589638.25	70.700

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
444866	422623	678312

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1142400.00	67.200
RUBBER	1686274.00	49.596

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
10617052	2687240	2687241

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	722400.12	60.200

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
614561	614561	1137954

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	220995	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
868000	220995	4562608
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	2546716	0

STATISTICS FOR PERIOD # 6

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	618828.37	74.200
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
449234	426772	657211

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1201900.00	70.700
RUBBER	1882352.00	55.363
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
9874967	2930039	2930040

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	806400.06	67.200
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
623976	623976	1134907

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	244169	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
700000	244169	5318439
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	2396029	0

STATISTICS FOR PERIOD # 7

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	648017.94	77.700
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
491961	467363	636234

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1261400.00	74.200
RUBBER	1980392.00	58.247
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
8875386	3079702	3079703

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	848400.31	70.700
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
686269	686269	1137500

```
 MAN  PRODUCT             PRODUCTION OUTPUT
FAN BELTS                           258111

 ORDERS  RECEIVED      SO SHIPMENTS      SO  BACKLOG
          616000          258111         6060328
 ORDER    SHIPMENTS      ORDER  BACKLOG      FINISHED PRODUCT  INVENTORY
               0          1898015                    0
```

STATISTICS FOR PERIOD # 8

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	671369.87	80.500
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTCRY
517673	491790	614740

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1320899.00	77.700
RUBBER	2078431.00	61.130
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
7900770	3229363	3229364.

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	890400.44	74.200
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
723749	723749	1142651

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	272053	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
560000	272053	6788275
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	1375206	0

STATISTICS FOR PERIOD # 9

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	636342.19	76.300
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
544545	517318	593830

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1368499.0C	80.500
RUBBER	2176469.00	64.014
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
7165069	3367719	3367720

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	932399.81	77.700
PURCHASES ORDERED	**SUPPLYS RECEIVED**	**BEGINNING RAW MATERIAL INVENTORY**
762061	762061	1151193

MAN PRODUCT	PRODUCTION OUTPUT
FAN BELTS	285052

ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
503999	285052	7503223
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	972561	0

STATISTICS FOR PERIOD #10

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	612990.19	73.500

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
570203	541693	574236

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1297100.00	76.300
RUBBER	2254900.00	66.321

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
6694645	3374400	3374401

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	965999.81	80.500

PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
798209	798209	1163600

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	284140	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
503999	284140	8219083
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	698511	0

STATISTICS FOR PERIOD #11

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	607152.06	72.800
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
568323	539907	551743

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1249500.00	73.500
RUBBER	2137254.00	62.860
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
6273945	3217416	3217417

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	915600.25	76.300
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
795599	795599	1171838

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	269588	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
560000	269588	8949495
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	573850	0

STATISTICS FOR PERIOD #12

RAW MATERIAL # 1

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
FIBER	577962.12	69.300
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
539203	512243	527749

RAW MATERIAL # 2

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
RUBBER	1237599.00	72.800
RUBBER	2058823.00	60.554
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
5929416	3131600	3131601

RAW MATERIAL # 3

SUPPLIER'S NAME	OUTPUT CAPABILITY	PERCENT OF NORMAL CAP.
SYN. CORD	882000.25	73.500
PURCHASES ORDERED	SUPPLYS RECEIVED	BEGINNING RAW MATERIAL INVENTORY
754848	754848	1175955

MAN PRODUCT	PRODUCTION OUTPUT	
FAN BELTS	262730	
ORDERS RECEIVED	SO SHIPMENTS	SO BACKLOG
588000	262730	9686765
ORDER SHIPMENTS	ORDER BACKLOG	FINISHED PRODUCT INVENTORY
0	588692	0

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Energy is vital to any production program and an energy shortage can substantially affect industrial production. The objective of this research project was to develop a system for analyzing the impact of various degrees of energy reductions (shortages) during crises on industrial production facilities participating in Industrial Preparedness Planning (IPP) programs. The researcher developed an Energy System Analysis Procedure (ESAP) for assessing the effects

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of energy reduction on production planning. The total energy requirements for manufacturing activities are analyzed for their effects on production. The method involves programming of the plant or facility in question from the viewpoint of physical units. The research recommended that the Air Force implement a system to evaluate the effects of energy reduction on IPP plant capabilities and work to enact an energy priority regulation for plants with the IPP program. Also, the research found that most IPP programs are out of date and are not being updated and reviewed periodically.